EVALUATION OF 3/4" CRUSHED STONE FROM A. G. ANDERSON CO., INC. HIGHGATE, VT. FOR USE IN STRUCTURAL CONCRETE

REPORT 85-8
MAY 1985

Reporting on Work Plan 85-C-5

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Date: 05-24-85

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ABSTRACT

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

This report documents results of tests performed on a newly developed coarse aggregate from the A. G. Anderson Co., Inc. quarry (formerly Gilles-Fortin quarry), located on TH 19 in Highgate, Vermont. The material tested was a 3/4" crushed stone.

Results indicate that the material performs satisfactorily.

INTRODUCTION

As new aggregate sources are developed for use in structural concrete, they 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 aggregate sources 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 Carl L. Anderson, President of A. G. Anderson, Co., Inc, to evaluate a crushed stone, designated by Mr. Anderson as a crushed limestone. Mr. Anderson indicated that the A. G. Anderson Co. would like to be able to use this crushed stone in ready mixed structural concrete produced for future Vermont Agency of Transportation projects.

Samples of the coarse aggregate 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.

PROCEDURES

PHASE I - SECTION 704.01 AND SECTION 704.02 TESTS

The proposed new coarse aggregate was sampled by representatives of the Materials & Research Division, from a stockpile at A. G. Anderson, Highgate, Vermont. The material was examined for gradation, percent of wear, fractured faces, thin and elongated pieces, and soundness. It was found to comply with Section 704.02 requirements. The reference coarse aggregate was sampled from a stockpile at the A. G. Anderson Ready Mixed Concrete Plant in Swanton, Vermont. The reference coarse aggregate was examined for gradation, percent of wear, thin and elongated pieces and fractured faces. The fine aggregate was sampled from a stockpile at the A. G. Anderson Ready Mixed Concrete Plant in Berlin, Vermont. The fine aggregate was examined for gradation and organic impurities. The reference coarse aggregate and the fine aggregate were found to comply respectively with Section 704.02 and Section 704.01 requirements. Fine aggregate test results are shown in Table 1. Coarse aggregate test results are shown in Table 2. Aggregate test results are also shown on Laboratory Report Nos. G85 0027, G85 0036, G85 0037, G85 0041 and G85 0042 in Appendix B.

TABLE 1

FINE AGGREGATE TEST DATA

	Fine Aggregate A.G. Anderson, Highgate, Vt. Date Sampled: 02/26/85	VT. A.O.T. Specification Requirements
Sieve Size	% Passing	% Passing
3/8"	100	100
#4	100	95-100
#8	86	-
#16	65	60-80
#30	41	25-60
#50	18	10-30
#100	5	2-10
Fineness Modulus	2.85	2.60-3.10
Organic Impurities, Color	1	2 Maximum

TABLE 2

COARSE AGGREGATE TEST DATA

	Proposed New Aggregate 3/4" Crushed Stone A.G. Anderson Co., Inc. Highgate, Vermont		Reference Aggregate 3/4" Crushed Stone Swanton Limestone Swanton, Vermont	
	Dates Sampled 02/12/85	02/20/85	Date Sampled 02/20/85	VT. A.O.T. Specification Requirements
Sieve Size	% Passing	% Passing	% Passing	% Passing
1"	100	100	100	100
3/4"	100	100	100	90-100
3/8"	38	35	46	20-55
#4	2	2	2	0-10
#8	1	1	1	0-5
L.A. Abrasion Percent Loss B Grading	23.5	23.9	27.7	35 Maximum
Thin & Elongated Pieces,%	4.2	2.2	1.2	10 Maximum
Fractured Faces, %	100	100	100	-

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

3/4" Crushed Stone
A. G. Anderson, Highgate, Vermont

B. Reference Aggregate

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

Fine Aggregate

A. G. Anderson, Highgate, Vermont

Cement

Type II
Northeast Portland Cement Co.
St. Constant, Quebec

Air Entraining Admixture

Daravair
W. R. Grace & Company
Cambridge, Massachusetts

Water Reducing Admixture

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

Aggregate properties used for preparing mix designs are shown in Table 3 and Table 4.

TABLE 3

COARSE AGGREGATE PROPERTIES

	Bulk Specific Gravity	Absorp. Percent	Dry Rodded Unit Weight Lbs./Ft.^{3}
New Aggregate A. G. Anderson Co., Inc. Highgate, Vermont	2.71	0.4	98.87
Reference Aggregate Swanton Limestone Swanton, Vermont	2.76	0.6	96.65

TABLE 4

FINE AGGREGATE PROPERTIES

	Bulk Specific Gravity	Absorp. Percent	Fineness Modulus
A. G. Anderson Co., Inc. Highgate, Vermont	2.59	1.4	2.80

The concrete used in this evaluation was mixed in a Sears rotary drum mixer with batch size being 1.8 cubic feet. Aggregates were dried prior to the start of mixing operations.

Two batches each of the Class A and Class B concrete containing the new coarse aggregate were prepared as well as two batches each of Class A and Class B containing the reference coarse aggregate.

The mix proportions used are shown in Table 5 and Table 6.

TABLE 5

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.	1655	1655	1655	1655
*Fine Aggregate, lbs.	1226	1226	1366	1366
Cement, lbs.	660	660	611	611
Air Entraining Admixture, oz.	5.5	5.5	3.6	3.6
Water Reducing Admixture, oz.	19.8	19.8	18.3	18.3
Net water, gal.	29.3	29.1	29.7	29.1

*Weights converted to saturated surface-dry condition.

TABLE 6

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.	1618	1618	1618	1618
*Fine Aggregate, lbs.	1289	1289	1429	1429
Cement, lbs.	660	660	611	611
Air Entraining Admixtures, oz.	5.5	5.5	5.0	4.1
Water Reducing Admixtures, oz.	19.8	19.8	18.3	18.3
Net Water, gal.	29.4	29.2	30.6	29.0

*Weights converted to saturated surface-dry condition.

Tests were performed on the fresh concrete to determine Slump (AASHTO T 119-82), Air Content (AASHTO T 152-84I) 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 22-84I), 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 161-83I) in a 3% NaCl solution.

RESULTS

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

TABLE 7

PERFORMANCE TEST RESULTS
NEW AGGREGATE

	Class A		Class B	
	Batch 1	Batch 2	Batch 3	Batch 4
Slump, inches	3	3	2 3/4	2 1/2
Air Content, percent	6.2	6.0	5.5	5.5
Unit Weight, lbs.ft.^{3}	145.45	145.88	146.65	146.89
Compressive Strength, psi				
7 days	4612	4748	4545	4603
14 days	4956	5067	4912	5080
28 days	5523	5527	5302	5448
(Design Compressive Strength,psi)	(4000)		(3500)	

TABLE 8

PERFORMANCE TEST RESULTS
REFERENCE AGGREGATE

	Class A		Class B	
	Batch 5	Batch 6	Batch 7	Batch 8
Slump, inches	3 1/4	3	2 1/4	2 1/2
Air Content, percent	6.5	6.4	6.6	6.1
Unit Weight, lbs/ft^3	145.78	145.83	145.50	145.64
Compressive Strength, psi				
7 days	4753	4718	4426	4488
14 days	5208	5098	4850	4996
28 days	5532	5576	5189	5588
(Design Compressive Strength, psi)	(4000)		(3500)	

The results of compressive strength tests are also shown on Laboratory Report Nos. C85 0111 through C85 0118 in Appendix C. Strength age plots illustrating average compressive strengths are shown in Figure I and Figure II.

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. Freeze-thaw test results are also summarized in Figure III and Figure IV. These figures show a comparison of results obtained with the reference aggregate and the new aggregate after 300 cycles of freezing and thawing.

TABLE 9

FREEZE-THAW TEST RESULTS - DURABILITY FACTOR

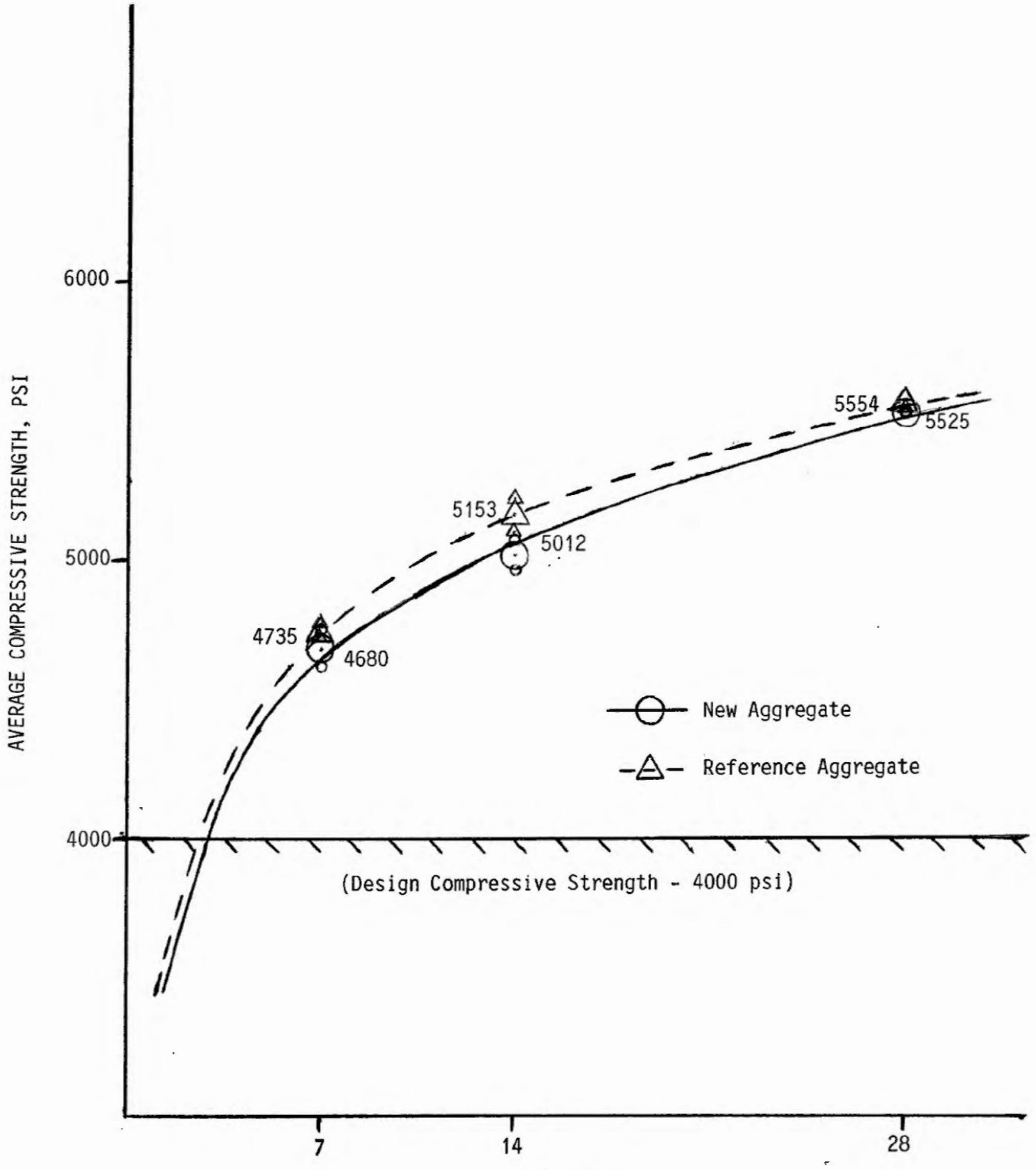
		New Aggregate				Reference Aggregate			
		Class A		Class B		Class A		Class B	
		Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
		Durability Factor							
Number of Cycles	50	98.2	98.9	98.2	98.9	99.6	99.3	99.3	98.6
	100	99.3	99.6	98.6	98.9	98.9	97.9	97.9	98.2
	150	98.6	99.6	98.6	98.6	98.9	97.9	97.9	98.2
	200	98.9	99.3	98.9	98.6	98.6	97.5	96.4	97.9
	250	97.8	98.9	97.8	98.2	98.2	97.2	97.1	97.1
	300	97.8	98.9	97.8	98.2	98.2	97.2	97.1	97.1

TABLE 10

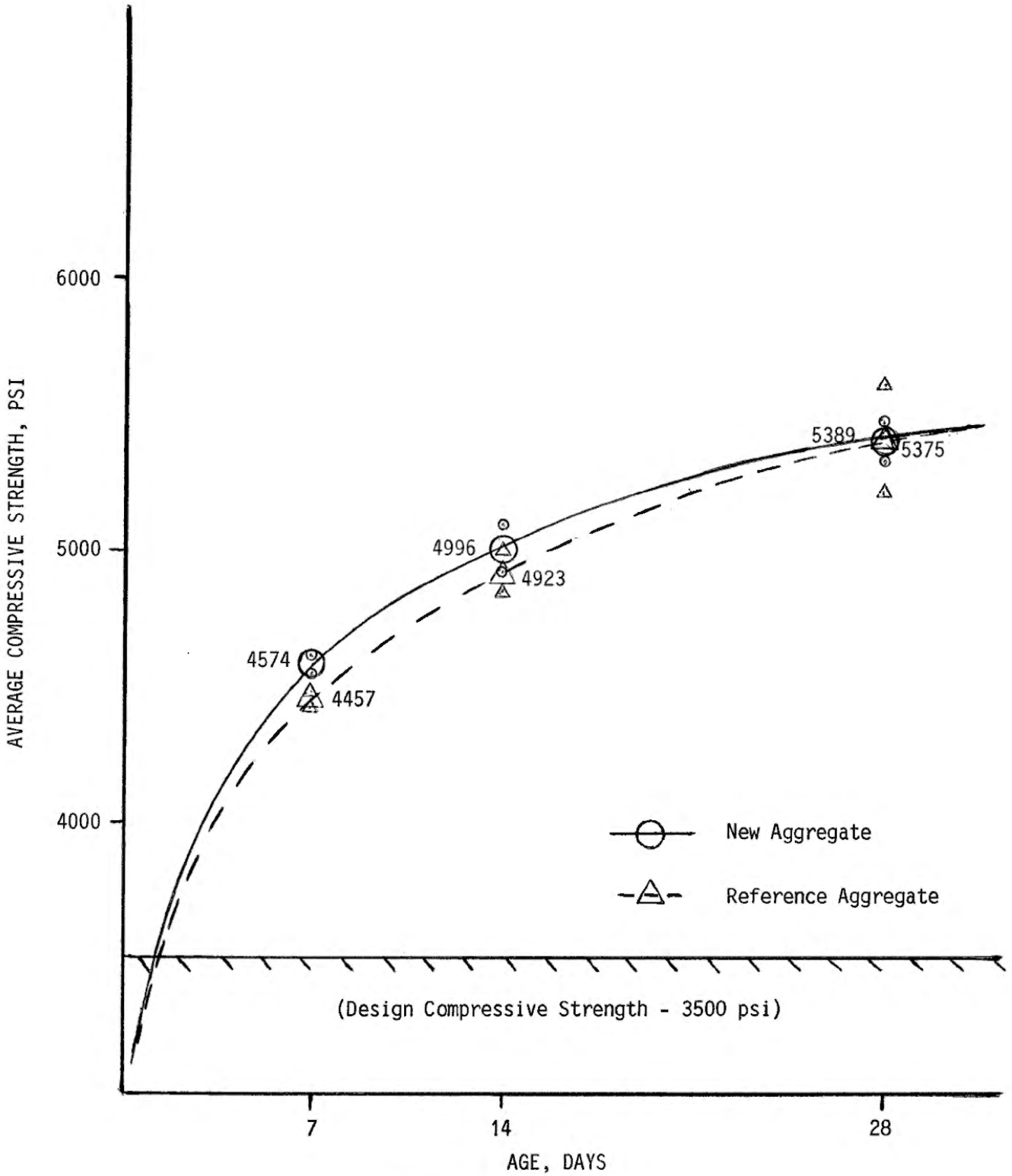
FREEZE-THAW TEST RESULTS - PERCENT WEIGHT LOSS

		New Aggregate				Reference Aggregate			
		Class A		Class B		Class A		Class B	
		Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
		Percent Weight Loss							
Number of Cycles	50	0.7	0.2	1.7	0.8	0.1	+0.1	1.1	1.5
	100	0.8	0.6	2.7	1.8	0.5	0.1	2.2	2.6
	150	0.8	0.4	3.6	2.5	0.5	0.5	2.9	3.5
	200	1.0	0.5	4.7	3.4	0.5	1.2	4.3	4.5
	250	2.0	0.9	6.1	5.3	0.7	1.0	5.2	6.0
	300	2.0	1.1	7.1	5.7	1.1	1.7	5.8	6.7

A(+) INDICATES WEIGHT GAIN



AVERAGE COMPRESSIVE STRENGTH VS AGE
CLASS A
FIGURE I



AVERAGE COMPRESSIVE STRENGTH VS AGE

CLASS B
FIGURE II

Batch Number	No. Cycles	Weight Lbs.	Percent Weight Loss	Fundamental Transverse Frequency "N"	"N"^{2}	Individual Durability Factor DF	Average DF	Relative Durability Factor RDF
Reference Aggregate								
5	0	12.41	1.1	1400	1960000	96.5	95.5	
5	300	12.27		1375	1890625			
6	0	12.43	1.7	1405	1974025	94.4		
6	300	12.22		1365	1863225			
New Aggregate								101.4
1	0	12.36	2.0	1395	1946025	95.7	96.8	
1	300	12.11		1365	1863225			
2	0	12.34	1.1	1395	1946025	97.9		
2	300	12.21		1380	1904400			

SUMMARY OF FREEZE-THAW TEST RESULTS

CLASS A

FIGURE III

Batch Number	No. Cycles	Weight Lbs.	Percent Weight Loss	Fundamental Transverse Frequency "N"	"N"^{2}	Individual Durability Factor DF	Average DF	Relative Durability Factor RDF
Reference Aggregate								
7	0	12.34	5.8	1400	1960000	94.4	94.4	
7	300	11.62		1360	1849600			
8	0	12.40	6.7	1400	1960000	94.4		
8	300	11.57		1360	1849600			
New Aggregate								101.8
3	0	12.38	7.1	1395	1946025	95.7	96.1	
3	300	11.50		1365	1863225			
4	0	12.52	5.7	1400	1960000	96.5		
4	300	11.81		1375	1890625			

SUMMARY OF FREEZE-THAW TEST RESULTS

CLASS B

FIGURE IV

SUMMARY AND CONCLUSIONS

1. The coarse aggregate from the A. G. Anderson Co., Inc. quarry in Highgate, Vermont, complied with all requirements of Section 704.02 when tested in conjunction with this evaluation.

2. The 28 day compressive strengths of concretes containing the Highgate coarse aggregate were approximately equal to the 28 day strengths of concretes containing the reference coarse aggregates.

3. The performance of the concretes containing the new aggregate and the concretes containing the reference aggregate were approximately equal when subjected to freeze-thaw testing. Results of sonic testing showed a minor increase in performance of the concrete containing the new aggregate when compared to concrete containing the reference aggregate with relative durability factors of 101.4 for Class A concrete and 101.8 for Class B concrete. The average weight loss results for the Class A and Class B concrete mixed with the new aggregate were respectively 0.2 and 0.1 percent greater than the weight loss results of Class A and Class B concrete containing the reference aggregate. The freeze-thaw results indicate satisfactory performance of the new aggregate.

RECOMMENDATIONS

1. It is recommended that the A. G. Anderson Co., Inc. Quarry (formerly Gilles-Fortin Quarry) in Highgate, Vermont be approved as a source of coarse aggregate for use in structural concrete.

2. During initial uses of concrete containing this aggregate on Agency projects, Materials and Research Division representatives shall conduct tests necessary to determine the performance of this aggregate in concrete under field conditions.

Appendix A

Prepared By: W. Meyer WFM
Date: March 26, 1982
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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.

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Rev. 2M 4/83
2M 6/84

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MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report 2-15, 19 85

Laboratory No. G85 0027 Tested By Armstrong

Name Coarse Aggregate for Concrete 501

Identification Marks Evaluation Sample 3/4" Crushed Stone

Submitted by Benda Title SCE Address

Sampled 2-12, 19 85 Received 2-12, 19 85 Testing Completed 2-13, 19 85

Sample from New Stockpile @ Anderson - Highgate

Quantity Represented

Source of Material Anderson - (Formerly Gillis-Fortin Quarry) Highgate

Project Name & Number W.P. No. 85-C-5

Examined for Item 704.02

TEST RESULTS

Total Sample Sieve Size	% Passing	Sand Portion
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"	38	
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 =

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

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96 23.5
B Grading
Fractured Faces, % 100

Thin & Elongated Pieces, % 4.2

Soundness, % Loss

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

By: R. F. Nicholson 1/17

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

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MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report 3/1, 19 85

Laboratory No. G85 0036 Tested By Morissette

Name Fine Aggregate for Concrete Item 501

Identification Marks Preliminary Sample

Submitted by Morissette Title PFP Address

Sampled 2/26, 19 85 Received 2/26, 19 85 Testing Completed 2/26, 19 85

Sample from Stockpile @ Anderson - Berlin

Quantity Represented

Source of Material Anderson - Highgate

Project Name & Number W.P. 85-C-5

Examined for 704.01

TEST RESULTS

Total Sample Sieve Size	% Passing	Sand Portion
4 1/2"		
4"		
3 1/2"		
3"		
2 1/2"		
2"		
1 3/4"		
1 1/2"		
1"		
3/4"		
5/8"		
1/2"		
3/8"		
No. 4	100	
No. 8	86	
No. 10		
No. 16	65	
No. 30	41	
No. 50	18	
No. 100	5	
No. 200		

Fineness Modulus
% Coarser Than

No. 100	95
No. 50	82
No. 30	59
No. 16	35
No. 8	14
No. 4	

Fineness Modulus = 2.85

Color = <1

Comments:
This material meets requirements for the tests indicated for item 704.01.

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96
Grading
Fractured Faces, %
Thin & Elongated Pieces, %
Soundness, % Loss

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

By: R.F. Nicholson 1/87
R. F. Nicholson, P.E., Materials & Research Engineer

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MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report 3/1, 19 85

Laboratory No. A85 0037 Tested By Lavin

Name Coarse Aggregate for Concrete 501.

Identification Marks Evaluation sample

Submitted by Benda Title SCE Address

Sampled 2/12, 19 85 Received 2/12, 19 85 Testing Completed 2/28, 19 85

Sample from new stockpile @ Anderson - Highgate

Quantity Represented

Source of Material Anderson Quarry - formerly Gillis-Fortin, Highgate

Project Name & Number W.P. 85-C-5

Examined for Item 704.02 Soundness only

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"	
5/8"	
1/2"	
3/8"	
No. 4	
No. 8	
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
Grading
Fractured Faces, %
Thin & Elongated Pieces, %
Soundness, % Loss 0.10

Comments:
This material was examined for soundness; the results are as indicated.

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

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

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MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report 3/18, 19 85

Laboratory No. G85 0041 Tested By Morissette

Name Coarse aggregate for concrete Item 501

Identification Marks Preliminary sample 3/4" crushed stone

Submitted by Morissette Title PFP Address

Sampled 2/20, 19 85 Received 2/20, 19 85 Testing Completed 3/1, 19 85

Sample from Stockpile @ Anderson - Swanton

Quantity Represented

Source of Material Swanton Lime

Project Name & Number Work Plan 85-C-5

Examined for 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"	46
No. 4	2
No. 8	1
No. 10	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

	Sand Portion

Fineness Modulus
% Coarser Than

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

Fineness Modulus =

Color =

Comments:

This material meets requirements for the tests indicated for item 704.02.

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96 27.7
B Grading
Fractured Faces, % 100

Thin & Elongated Pieces, % 1.2

Soundness, % Loss

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

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

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MATERIALS & RESEARCH DIVISION
Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report 3/18, 1985

Laboratory No. G85 0042 Tested By Morissette

Name Coarse aggregate for concrete Item 501

Identification Marks Evaluation sample 3/4" crushed stone

Submitted by Morissette Title PFP Address

Sampled 2/20, 1985 Received 2/20, 1985 Testing Completed 3/1, 1985

Sample from Stockpile @ Anderson - Highgate

Quantity Represented

Source of Material Anderson - Highgate

Project Name & Number Work Plan 85-C-5

Examined for 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"	35
No. 4	2
No. 8	1
No. 10	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

Sand Portion

Fineness Modulus % Coarser Than

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

Fineness Modulus =

Color =

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

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96 23.9
B Grading
Fractured Faces, % 100

Thin & Elongated Pieces, % 2.2

Soundness, % Loss

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

By: R. F. Nicholson 1/87
R. F. Nicholson, P.E., Materials & Research Engineer

mlm

Project Name
Work Plan
Project Number
85-C-5

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0111 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab ÷ Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 611

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

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3047

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Reference Mix Batch No. 7

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

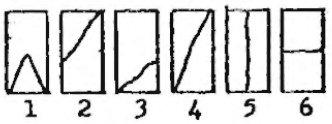
Unit Weight Fresh Concrete 145.50 Air: Pressure 6.6 Chace

Total Water, Gal/Cy Used 30.58 Slump 2¼ Temperature, Concrete 68 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
R-1-B	1	145	3-5	3-11	7	7	S	4368	4483	4426		
	2	146										
	3	146	3-5	3-18	14	14	S	4810.	4890	4850		
	4	146										
	5	146	3-5	4-1	28	28	S	5084	5288	5186		
	6	146										

*S = Standard Cured; F = Field Cured

Types of Breaks:



mlm

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

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

By: R. F. Nicholson /RAT

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

Project Name
Work Plan
Project Number
85-C-5

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C850122 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 611

Air Entraining Admixture Daravair Dosage 4.1 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3047

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Reference Mix Batch No. 8

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

Unit Weight Fresh Concrete 145.64 Air: Pressure 6.1 Chace

Total Water, Gal/Cy Used 29.04 Slump 2½ Temperature, Concrete 69° 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
R-2-B	1	146										
	2	147	3-5	3-11	7	7	S	4492	4483	4488		
	3	146										
	4	146	3-5	3-18	14	14	S	4925	5067	4996		
	5	146										
	6	146	3-5	4-1	28	28	S	5588	5588	5588		

*S = Standard Cured; F = Field Cured

Types of Breaks:

mlm

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

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

By: R. F. Nicholson 1847

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

Project Name
Work Plan
Project Number
85-C-5

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0113 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 660

Air Entraining Admixture Daravair Dosage 5½ oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 2907

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Reference Mix Batch No. 5

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

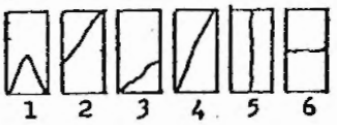
Unit Weight Fresh Concrete 145.78 Air: Pressure 6.5 Chace

Total Water, Gal/Cy Used 29.42 Slump 3¾ Temperature, Concrete 70 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
R-3-A	1	145										
	2	146	3-5	3-11	7	7	S	4775	4731	4753		
	3	146										
	4	145	3-5	3-18	14	14	S	5199	5217	5208		
	5	145										
	6	146	3-5	4-1	28	28	S	5394	5668	5531		

*S = Standard Cured; F = Field Cured

Types of Breaks:



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

By: R. F. Nicholson /RAF

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

mlm

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

Project Name
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Montpelier, Vermont 05602

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CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0114 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 660

Air Entraining Admixture Daravair Dosage 5½ oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 2907

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Reference Mix Batch No. 6

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

Unit Weight Fresh Concrete 145.83 Air: Pressure 6.4 Chace

Total Water, Gal/Cy Used 29.17 Slump 3 Temperature, Concrete 70 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
R-4-A 1	145										
2	145	3-5	3-11	7	7	S	4775	4660	4718		
3	145										
4	145	3-5	3-18	14	14	S	5049	5150	5100		
5	145										
6	146	3-5	4-1	28	28	S	5562	5588	5575		

*S = Standard Cured; F = Field Cured

Types of Breaks:

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

By: R. F. Nicholson /RAT

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

mlm

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

Project Name
Work Plan
Project Number
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STATE OF VERMONT
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MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0115 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 611

Air Entraining Admixture Daravair Dosage 3.6 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3021

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Test Mix Batch #3

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

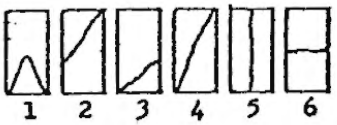
Unit Weight Fresh Concrete 146.65 Air: Pressure 5.5 Chace

Total Water, Gal/Cy Used 29.68 Slump 2 3/4 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
H-1-B	1	146										
	2	146	3-5	3-11	7	7	S	4563	4527	4545		
	3	146										
	4	147	3-5	3-18	14	14	S	4784	5040	4912		
	5	146										
	6	147	3-5	4-1	28	28	S	5341	5261	5301		

*S = Standard Cured; F = Field Cured

Types of Breaks:



mlm

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

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

By: R. F. Nicholson 1987

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

Project Name
Work Plan
Project Number
85-C-5

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0116 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 611

Air Entraining Admixture Daravair Dosage 3.6 oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 3021

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Test Mix Batch No. 4

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

Unit Weight Fresh Concrete 146.89 Air: Pressure 5.5 Chace

Total Water, Gal/Cy Used 29.09 Slump 2½ Temperature, Concrete 71 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
H 2-B 1	146										
2	146	3-5	3-11	7	7	S	4660	4554	4607		
3	146										
4	146	3-5	3-18	14	14	S	5075	5084	5080		
5	147										
6	146	3-5	4-1	28	28	S	5403	5491	5447		

*S = Standard Cured; F = Field Cured

Types of Breaks:

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

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

mlm

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

Project Name: Work Plan
Project Number: 85-C-5

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

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0117 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 660

Air Entraining Admixture Daravair Dosage 5½ oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 2881

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Test Mix Batch #1

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

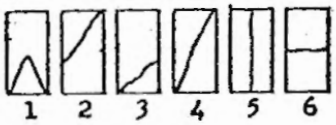
Unit Weight Fresh Concrete 145.45 Air: Pressure 6.2 Chace

Total Water, Gal/Cy Used 29.29 Slump 3 Temperature, Concrete 70 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
H-3-A 1	145										
2	145	3-5	3-11	7	7	S	4695	4527	4611		
3	146										
4	145	3-5	3-18	14	14	S	5075	4837	4956		
5	145										
6	146	3-5	4-1	28	28	S	5464	5579	5522		

*S = Standard Cured; F = Field Cured

Types of Breaks:



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

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

mlm

Comments:
TA 183H Rev.
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Project Name
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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION
Montpelier, Vermont 05602

Benda
CF

Report on Concrete Test Beam or Cylinders

Laboratory No. C85 0118 (28) Report of 28 Day Breaks Date typed 4/4/85

Pay Item Performance in Concrete Type of Sample Evaluation

Submitted by Meyer Title PFP Address

Source of Material Mat. & Res. Lab - Berlin Quantity Represented 1.8 c,f,

Coarse Aggregate Swanton Limestone Fine Aggregate Anderson - Highgate

Cement Brand Northeast Type II Lbs. 660

Air Entraining Admixture Daravair Dosage 5½ oz/cy Admixture WRDA Hycol Dosage 3 oz/cwt

Maximum allowable water content, Gal/Cy Total Aggregate, Dry Wgt. 2881

Field Tested by Structural Concrete Subdivision Lab. Tested by Reed

Sampled from Laboratory Mixer Date Sampled: 3/4/85

Location Used or to be Used Test Mix Batch No. 2

Examined for Mod. of Rupture Compressive Strength

TEST RESULTS

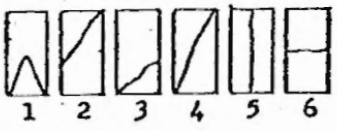
Unit Weight Fresh Concrete 145.88 Air: Pressure 6.0 Chace

Total Water, Gal/Cy Used 29.09 Slump 3 Temperature, Concrete 70 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
H-4-A 1	146										
2	146	3-5	3-11	7	7	S	4801	4695	4748		
3	146										
4	144	3-5	3-18	14	14	S	5137	4996	5067		
5	145										
6	145	3-5	4-1	28	28	S	5518	5535	5527		

*S = Standard Cured; F = Field Cured

Types of Breaks:



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

By: R. F. Nicholson 4/87.

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: Frank J. Lanza, Chief Geologist via R. F. Nicholson, P.E.
Materials & Research Eng.

DATE: April 26, 1985

SUBJECT: A. G. Anderson Co., Inc., Gilles Fortin Quarry Rock, Highgate, VT

At the request of the Structural Concrete Engineer, a petrographic field examination of the Gilles Fortin Quarry and quarry rock was conducted on April 17, 1985 as a supplement to the evaluation of a new aggregate source for use in structural concrete by A. G. Anderson Co., Inc.

Hand samples of the blasted quarry rock were collected for office examination as well as two bags of 3/4 inch minus rock for abrasion tests according to AASHTO T-96 method.

The rock in the Gilles Fortin Quarry in Highgate, Vermont was first sampled by the Engineering Geology Subdivision in 1959 as a possible source of crushed rock for sub-base for the construction of Interstate 89 and was subsequently used as Sub-base of Crushed Rock, Pay Item 201 for the construction of I 89 in that area.

The rock examined in the Gilles Fortin quarry belongs to the Shelburne Formation of Ordivician Age. It is a light to medium gray colored limestone (predominantly ($CaCO_3$) calcium carbonate)fine grained, firm and readily effervesceses with cold dilute hydrochloric acid. The rock in the quarry is fairly well jointed and appears to be free of deleterious or unsound substances uniform in nature with only slight variations in shades of the color gray.

Two sample bags of 3/4 inch minus crushed stone from the Gilles Fortin Quarry were taken from a stockpile and examined for abrasion (according to AASHTO T-96), gradation and thin and elongated pieces. Both preliminary samples met the requirements for coarse concrete aggregate for concrete, Item 501 (see attached Laboratory Sheets).

The mineralogical composition of the rock is generally performed on thin sections with a stereoscopic microscope. Only those characteristics that could be determined megascopically with a hand lens were noted. No chemical tests were performed, other than with dilute hydrochloric acid to determine the presence of a carbonate.

With respect to alternate sources, the gray limestone from Swanton Limestone Quarry in Swanton, Vermont, is a blue gray limestone of the Beldens Formation of Ordivician Age. Although the rocks from the Gilles Fortin Quarry and the Swanton Limestone Quarry are both of Ordivician Age and are both limestones, they are from different formations. Any chemical differences between the two limestones would have to be determined by chemical analysis. Physically, the rocks appear similar and in that respect can be compared and are very similar (hardness, particle shape, etc.).

Petrographic analysis of rock samples in the field is visual; only those attributes relating to surface texture, hardness, coating variations in strata, deleterious and unsound substances, can be determined. Chemical attributes require the use of petrographic and stereoscopic microscope, and the preparation of thin section for analysis.

RFN:FJL:etn

Attachments

cc: RFN/Lab File
F. Lanza
R. Fraser

Appendix E

TA 565 Rev. 4/79

Prepared By: W. L. Meyer
Date: 02/08/85
Sheet 1 of 1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 85-C-5

Subject Evaluation of Crushed Stone Coarse Aggregate, A. G. Anderson Co., Inc.,Highgate, VT

Investigation Requested By Carl L. Anderson Date Received 02/07/85

Date Information Required As soon as possible

Purpose of Investigation To evaluate a crushed stone coarse aggregate from the A. G. Anderson Co., Inc. quarry (formerly Gillis-Fortin Quarry), proposed for use as a structural concrete aggregate. Quarry is located on TH 19 in Highgate, Vermont

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

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

Investigation To Be Conducted By Structural Concrete Subdivision

Proposed Starting Date February 15, 1985 Estimated Completion Date May 15, 1985, including report

Approval/Disapproval by Materials & Research Engineer R. F. Nicholson 02-15-85

Comments by Materials & Research Engineer

Materials & Research Division
Agency of Transportation
Date Typed: February 13, 1985