PRELIMINARY EVALUATION OF MANUFACTURED SAND FROM FRANK W. WHITCOMB/WINOOSKI, VT. FOR USE IN STRUCTURAL CONCRETE

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REPORT 84-2 APRIL 1984

REPORTING ON WORK PLAN 83-C-7

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ABSTRACT

This report documents results of a preliminary investigation of manufactured sand from the Frank W. Whitcomb Construction Corp. quarry in Winooski, Vermont, for use in structural concrete.

Tests were performed to determine compliance with the requirements of Section 704.01 of the <u>Vermont Standard Specifications for Highway</u> <u>and Bridge Construction</u>. Concrete mixes containing the proposed new material were examined for compressive strength and resistance to freezing and thawing. Results of tests were compared to results obtained from concrete mixes containing a reference fine aggregate.

Limited availability of the proposed new material necessitated performing fewer tests than had been originally scheduled.

This report recommends that, when sufficient quantities of this material are available, all tests originally planned for this evaluation be completed and a final report prepared.

INTRODUCTION

This report documents results of a preliminary investigation of manufactured sand, proposed for use in structural concrete. The request for this evaluation was submitted by the Frank W. Whitcomb Construction Corp. of Bellows Falls, Vermont, which also requested the material be evaluated for use in bituminous concrete.

The request indicated sufficient quantities of material were available for testing purposes, but failed to state the source and location of the material or the manufacturing process involved.

It was eventually learned the source of material was a quarry belonging to the Frank W. Whitcomb Construction Corp., located in Winooski, Vermont. Parent material from the quarry was transported to Rexnord, Inc., Milwaukee, Wisconsin, where the manufactured sand was produced, using a Gyradisc crusher. Samples of the manufactured sand were available at the Frank W. Whitcomb Construction Corp. facility in North Walpole, New Hampshire.

The request also indicated the Frank W. Whitcomb Construction Corp. was aware that the proposed material is currently prohibited from being used as the only fine aggregate in bituminous or structural concrete. Present specifications permit a combination of washed natural sand and stone screenings, but limit stone screenings to not more than 50 percent, by weight, of the combination.

The manufactured sand, as submitted, failed to comply with grading requirements for Section <u>704.01 FINE AGGREGATE FOR CONCRETE</u>. Prior to its use in structural concrete mixes, the material was separated on appropriate screens and recombined to provide a grading which met requirements. Limited availability of the material also required that fewer trial batches

be prepared than had been originally scheduled.

The modified performance-in-concrete phase of this evaluation was conducted in the Central Laboratory of the Materials and Research Division, using coarse aggregate from the Winooski quarry and a reference fine aggregate from Hinesburg Sand and Gravel Company, Inc., in Hinesburg, Vermont. Results of tests performed on concrete containing the new fine aggregate were compared with results obtained from concrete containing the reference fine aggregate. The Class B concrete used in this evaluation was examined for compressive strength and resistance to freezing and thawing.

A concurrent investigation of the proposed material, conducted by the Bituminous Concrete Subdivision, is documented in Materials and Research Division Report 83-4.

MATERIALS

The materials used in this investigation are as follows:

a. Coarse Aggregate:

3/4" Crushed Stone F. W. Whitcomb Construction Corp. Winooski, Vt.

b. Fine Aggregate:

- A. Proposed New Aggregate (Manufactured Sand)
 F. W. Whitcomb Construction Corp.
 Winooski, Vt.
- B. Reference Aggregate Hinesburg Sand & Gravel Company, Inc. Hinesburg, Vt.

c. Cement:

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

d. Air Entraining Admixture:

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

e. Water Reducing Admixture:

WRDA with Hycol W. R. Grace & Co. Cambridge, MA Aggregate properties used for preparing mix designs are shown in Table 1 and Table 2.

TABLE 1 COARSE AGGREGATE PROPERTIES

	Bulk Specific Gravity	Absorption, percent	Dry Rodded Unit Weight, 1bs/ft ³
Reference Aggregate-Whitcomb, Winooski	2.78	0.4	100.32

TABLE 2 FINE AGGREGATE PROPERTIES

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	Bulk Specific Gravity	Absorption, percent	Fineness Modulus
Reference Aggregate - Hinesburg S&G/Hinesburg	2.64	0.9	2.72
Manufactured Sand - Whitcomb/Winooski	2.61	0.8	2.78

PROCEDURES

Samples of the proposed new material were obtained from the manufacturer and tested for compliance with Section 704.01. The material was examined for gradation, organic impurities, and compressive strength of mortar. Soundness test results were obtained from the Bituminous Concrete Subdivision which conducted a concurrent evaluation of the material.

The specific gravity used to prepare mix designs was also obtained from the Bituminous Concrete Subdivision.

Preliminary gradation tests, which agreed with data submitted by the manufacturer, indicated the material did not comply with requirements. Prior to preparing trial batches, the material was separated on the appropriate screens and recombined to provide an acceptable gradation.

Performance-in-concrete tests were conducted on concrete prepared in the Central Laboratory. Mixtures were designed by Structural Concrete Subdivision personnel for Class B concrete. Plans to investigate Class A concrete were abandoned, due to a lack of sufficient new material.

Concrete used in this evaluation was mixed in a Sears rotary drum mixer with batch size being one cubic foot. Two batches of Class B concrete containing the new aggregate were prepared, as well as two batches of Class B concrete containing the reference aggregate.

The mix proportions used are shown in Table 3.

TABLE 3

CLASS B CONCRETE MIX DESIGNS BATCH QUANTITIES PER CUBIC YARD

	New Age	gregate	Reference	Aggregate
	Batch 1	Batch 2	Batch 3	Batch 4
*Whitcomb Coarse Aggregate, 1bs *Whitcomb Fine Aggregate, 1bs. *Hinesburg Fine Aggregate, 1bs. Cement, 1bs. Air Entraining Admixture of	1686 1405 - 611 3 9	1686 1405 - 611 3 9	1686 - 1423 611 3 0	1686
Water Reducing Admixture, oz. Net Water gal.	18.3 37.2	18.3 37.3	18.3 34.8	18.3 34.3

*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 152-82), and Unit Weight (AASHTO T 121-82). Three test cylinders (6" x 12") and one freeze-thaw specimen (3" x 3" x 16") were cast from each batch. The cylinders were tested for compressive strength (AASHTO T 22-82) at 28 days. The freeze-thaw specimens were moist cured for 14 days, after which they were subjected to 500 cycles of freezing and thawing (AASHTO T 161-82) in a 3% NaCl solution.

a. Gradation (AASHTO T 27-82)

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		Proposed New	Aggregate	•		
Sieve Size	Manufacturer's Data % Passing	Bituminous Concrete <u>Subdivision</u> % Passing	Structural Concrete Subdivision % Passing	Laboratory Graded <u>Material</u> % Passing	Reference Aggregate % Passing	V.A.O.T. Specification Requirements % Passing
3/8" No. 4 No. 8 No. 16 No. 30 No. 50 No. 100 No. 200	100 100 92 53 32 20 11 5	100 100 95 63 38 24 14 5	100 100 94 59 36 23 13 5	100 100 94 60 35 23 10 3	100 98 81 68 49 24 8 2	100 95-100 - 50- 80 25- 60 10- 30 2- 10 -
Fineness Modulus	2.92	2.66	2.75	2.78	2.72	2.60 - 3.10

Results of tests on the proposed new fine aggregate and reference fine aggregate are as follows:

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b. Organic Impurities (AASHTO T 21-81)

	Proposed New Aggregate	Reference Aggregate	V.A.O.T. Specification Reguirements
Color Plate	<1	1	2 maximum

c. Compressive Strength of Mortar

(1) Proposed new aggregate test results.

	Ottawa Sand, Avg. psi	Proposed New Aggregate, Avg. psi	Proposed New Aggregate, Percent of Ottawa Sand	V.A.O.T. Spec. Subsection 704.01(c) Requirements, percent of Ottawa Sand
3 days	2680	4540	169	100 minimum
7 days	3260	4950	152	100 minimum

(2) Reference aggregate test results.

	Ottawa Sand, Avg. psi	Reference Aggregate, Avg. psi	Reference Aggregate, percent of Ottawa Sand	Subsection 704.01(c) Requirements, percent of Ottawa Sand
3 days	2400	4170	174	100 minimum
7 days	3050	5050	166	100 minimum

d. Soundness, Using Sodium Sulfate (AASHTO T 104-77)

*Proposed New Aggregate, percent loss	Reference Aggregate, percent loss	V.A.O.T. Specification Requirements, percent loss
6.0	2.2	8 maximum

*Results from Materials & Research Division Report 83-4

Coarse aggregate test results are as follows:

a. Gradation (AASHTO T 27-82)

	3/4" Crushed Stone	V.A.O.T. Specification Requirements
Sieve Size	Percent Passing	Percent Passing
יין	100	100
3/4"	99	90-100
3/8"	26	20- 55
No. 4	4	0-10
No. 8	1	0- 5

b. Thin and/or Elongated Particles (VT AOT-MD 22)

3/4"	Crushed percent	Stone,	V.A.O.T. Specification Requirements, percent
	3.0		10 maximum

c. Los Angeles Abrasion, "B" Grading (AASHTO T 96-77)

	V.A.O.T.
	Specification
3/4" Crushed Stone,	Requirements,
percent loss	percent loss

15.1 35 maximum

d. Soundness, Using Sodium Sulfate (AASHTO T 104-77)

	V.A.O.T. Specification		
3/4" Crushed Stone, percent loss	Requirements, percent loss		
0.3	8 maximum		

The results of tests on the fresh and hardened concrete are shown in Table 4.

TABLE 4

CLASS	В	CONCRETE	TEST	RESULTS

	New Aggregate		Reference Aggregate	
	Batch 1	Batch 2	Batch 3	Batch 4
Slump, inches Air Content, percent Unit Weight, lbs/ft ³ Temperature, °F	3 5.0 146.1 72	2 1/2 5.1 146.1 72	3 1/2 4.8 - 74	4 3/4 5.3 147.7 70
*Compressive Strength, psi 28 days Freeze-Thaw Durability	5871	5986	5836	5600
@ 250 cycles @ 500 cycles	5.3 7.1	3.9 6.1	5.4 9.5	3.6 7.7
Durability Factor @ 500 cycles	88.2	95.1	73.4	95.8

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*Design Compressive Strength 3500 psi

SUMMARY AND CONCLUSIONS

- The sample of proposed new aggregate, submitted by the manufacturer, contained an excess of material passing the No. 100 sieve. All other aggregate test results complied with specification requirements.
- 2) The net water (see Table 3) required with the New Aggregate batches exceeded the "Maximum Water Cement Ratio" permitted by specifications. The average 37.25 gal/yd³is equal to a water/cement ratio of .51. The maximum allowable water/cement ratio for Class B concrete is .49. The net water also averaged 2.75 gal/yd³ higher than that required in the reference concrete. The increased water demand can generally be attributed to the greater angularity of the aggregate particles, when compared to natural sand.
- 3) The angularity of the aggregate particles is also considered to be responsible for the increased quantity of air entraining admixture required in the concrete batches containing the manufactured sand.
- 4) The compressive strength of concrete containing the manufactured sand was slightly higher than the strength of the concrete containing the reference aggregate.
- 5) The concrete containing the manufactured sand showed slightly less weight loss in freeze-thaw testing when compared to the concrete containing the reference aggregate. Sonic testing produced variable results. Testing indicated the first batch of concrete containing the manufactured sand and the first mixture with the reference aggregate were less durable than their respective second batches.

RECOMMENDATIONS

Should the Frank W. Whitcomb Construction Corp. install the necessary equipment and begin producing manufactured sand at the Winooski, Vermont quarry, the following recommendations should be carried out:

- The evaluation be continued until all tests originally scheduled are completed.
- Prepare a final report documenting results of all tests and make recommendations relative to possible future use of the proposed new material including, if necessary, changes in specifications.

APPENDIX

Date: 2/3/83 WIM Sheet 1 of 2

STATE OF VERMONT AGENCY OF TRANSPORTATION MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 83-C-7

Subject Evaluation of a Proposed New Fine Aggregate, Frank W. Whitcomb Const. Corp. Winooski, Vt.

Investigation Requested By Frank W. Whitcomb Cons. CorpDate December 10, 1982-

Date Information Required As soon as possible

Purpose of Investigation To evaluate a new fine aggregate (manufactured sand)

from the Frank W. Whitcomb Construction Corp., Winooski, Vermont quarry

for use as a structural concrete aggregate.

Proposed Tests or Evaluation Procedure

See Vermont Procedure For Evaluating a New Source of Structural Concrete

Aggregate, VT-AOT-MRD 9-82. This procedure will be used as a guide for

investigating the proposed new material. Several modifications may be

necessary to complete the required evaluation, including:

(1) Material already examined failed to meet grading requirements.

Rescreening may be necessary to achieve an acceptable

gradation.

(See sheet two)

D. Brown Proposal Discussed With R. Frascoia Projected Manpower Requirements 40 man days Investigation To Be Conducted By <u>Structural Concrete Subdivision</u> Proposed Starting Date <u>February 15, 1983</u> Estimated Completion Date <u>May 25, 1983</u> Approval/Disapproval by Materials Engineer <u>Ref. Achol.</u> 2-4-83 Comments by Materials Engineer

Materials & Research Division Agency of Transportation Date Typed: February 3, 1983 Vt. Agency of Transportation Research Investigation Work Plan No. 83-C-7

APPENDIX, con't.

- (2) Initial 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.
- (3) Present specifications permit not more than 50%, by weight, of stone screenings. The fine aggregate proposed consists of 100% crushed material. Additional performance-in-concrete tests, using various proportions of the proposed new material blended with a reference washed natural sand, may be necessary in order to establish a mix design to be evaluated under field conditions.
- (4) Conduct a field evaluation of ready mixed concrete containing the proposed new material, or blended new material, to examine slump, air content, compressive strength, workability and finishing characteristics.

Prepare a progress report at the completion of each phase of the evaluation, and a final report when all testing has been completed.