

STRENGTH EVALUATION
OF A TYPE IV MORTAR
VENUS MULTI-LEAF ALUMINUM NO. 195

REPORT 82-1
JANUARY 1982

REPORTING ON WORK PLAN 81-C-16


STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Technician B

Reviewed By:


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

Date: Feb. 9, 1982

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ABSTRACT

This report documents laboratory and field testing of a Type IV non-shrinking cement mortar. Venus Multi-Leaf Aluminum No. 195 was selected as the aluminum powder admixture, based on its past history of successful use on Vermont Agency of Transportation projects. Mixing procedures outlined in Subsection 707.04 Mortar, Type IV of the Vermont Agency of Transportation Standard Specifications were followed in the laboratory and field mixes. High compressive strengths were exhibited from the laboratory mix and field mixes that were tested.

INTRODUCTION

A request was received from the Structures Division to evaluate the compressive strength of a Type IV mortar. The mortar was to be used under the steel frame leg bearing plates for BR #1 on the Waterford - St. Johnsbury I 93-1(3) C/1 project.

The Structural Concrete Subdivision had tested a number of non-shrinking cement mortars with the results presented in the report "NON-SHRINKING CEMENT MORTAR & GROUT EVALUATION REPORT", August 1, 1974, revised December 17, 1976. The tests in that report indicated that Venus Multi-Leaf Aluminum No. 195 was one of the better aluminum powder admixtures. The request to evaluate a Type IV mortar presented an opportunity to gain more information about this admixture.

MATERIALS

SAND:

Fine Aggregate for Concrete (Item 704.01)
Lawrence Sangravco, Guildhall, Vt.

CEMENT:

Type II
Glens Falls Portland Cement Company, Inc.
Glens Falls, N.Y.

ALUMINUM POWDER:

Venus Multi-Leaf Aluminum No. 195
U.S. Bronze Powders, Inc.
Flemington, N.J.

PROCEDURES

LABORATORY

The Type IV mortar was designed and mixed according to Subsection 707.04 Mortar Type IV of the Vermont Agency of Transportation Standard Specifications with two exceptions.

- 1) Item 704.01, Fine Aggregate For Concrete, was substituted for Item 704.19, Sand For Cement Mortar. Because of the lack of availability of mortar sand in the area, this change was requested by the Resident Engineer. It was felt that a slight loss of workability which could result from substituting Item 704.01 would not affect the intended use of the Type IV mortar.
- 2) Portland cement was substituted for pozzolan or pumicite as the dispersing agent for the aluminum powder admixture. In past experiences, cement has performed well as the dispersing agent.

The following design was used for the laboratory mix:

Sand	94 lbs. (dry)
Cement	94 lbs.
Aluminum Powder	3 grams
Net Water	30.5 lbs. (Plastic Fluidity)

This mix design was calculated to yield approximately 1 1/2 c.f. of mortar.

The mortar was mixed in a 1 1/2 c.f. rotary drum mixer. Immediately following mixing, a unit weight test was performed while twelve 2" cubes and eight 4"x8" cylinders were cast. The cube molds were covered with brass plates and the cylinder molds were covered with glass plates. Weights were placed on the plates to keep the mortar restrained.

After twenty four hours the cubes and cylinders were removed from the molds. Three cubes and two cylinders were tested for compressive strength at the age of one day. The remaining cylinders and cubes were cured under standard fog room conditions until tested at the ages of 3, 7, and 28 days.

FIELD

The following mix design was recommended for use on the project:

Sand	94 lbs. (dry)
Cement	94 lbs.
Aluminum Powder	3 grams
Water/Cement Ratio	.33 maximum

To insure that the correct mix proportions would be used on the project, three precautionary steps were followed:

1. The mix was designed to use a full bag of cement which eliminated the weighing of cement.
2. The aluminum powder was preweighed, blended one part aluminum powder to fifty parts cement, and placed in individual containers for each batch of mortar.
3. The sand was preweighed and bagged with adjustments made for aggregate moisture.

The mortar was mixed in a rotary drum mixer at the job site. The contractor followed the correct mixing procedure outlined in Sub-section 707.04 Mortar Type IV of the Vermont Agency of Transportation Standard Specifications. Water was added as needed to obtain a plastic fluidity.

Six 2" cubes were cast from each of two random mixes. The method used to restrain the field mortar cubes was the same as followed in the laboratory. The cubes were field cured outside of the work area where they would not be disturbed.

After two days the cubes were transported to the Materials and Research Division Laboratory and cured under standard fog room conditions. Cubes from each mix were tested for compressive strength, three each at 7 and 28 days.

TEST RESULTS

LABORATORY

The unit weight test on the laboratory mix indicated a unit weight of 139.03 lbs/ft³.

The compressive strength test results on the laboratory mix are as shown in Table 1 and Table 2.

TABLE 1
COMPRESSIVE STRENGTHS, PSI
4"x8" CYLINDERS

AGE	SPECIMEN NO.		AVE.
	1	2	
1 Day	4039	4218	4129
3 Day	5332	5391	5362
7 Day	6187	6068	6128
28 Day	7003	7381	7192

TABLE 2
 COMPRESSIVE STRENGTHS, PSI
 2" CUBES

AGE	SPECIMEN NO.			AVE.
	1	2	3	
1 Day	4400	4438	4338	4392
3 Day	6450	6475	6388	6438
7 Day	7263	7325	7025	7204
28 Day	8150	7988	7800	7979

FIELD

The compressive strength test results on the field mixes are shown in Table 3.

TABLE 3
 COMPRESSIVE STRENGTHS, PSI
 2" CUBES

Field Mix #1

AGE	SPECIMEN NO.			AVE.
	1	2	3	
7 Day	7575	7313	7538	7475
28 Day	8575	8125	7788	8163

Field Mix #2

AGE	SPECIMEN NO.			AVE.
	4	5	6	
7 Day	8475	8338	8625	8479
28 Day	9075	8600	9100	8925

SUMMARY AND CONCLUSIONS

- 1) Venus Multi-Leaf Aluminum No. 195, used as an aluminum powder admixture, provided a high strength Type IV mortar.
- 2) Compressive Strengths obtained from Laboratory mixes will closely approximate field strengths provided exact mix proportions and mixing procedures are followed in the field. Close monitoring of the field operation is a must for this type of mix.
- 3) The substituting of Item 704.01, Fine Aggregate for Concrete, for Item 704.19, Sand for Cement Mortar, did not appear to have a negative affect on strength or workability.
- 4) Portland cement performed well as the dispersing agent for the aluminum powder admixture.

RECOMMENDATIONS

- 1) The precautions taken to ensure correct mix proportions on this project should be followed in future use of Type IV mortar.
- 2) Item 704.01, Fine Aggregate for Concrete, can be used to replace Item 704.19, Sand for Cement Mortar, when the latter is not readily available.
- 3) A change should be made in subsection 707.04, Mortar, Type IV in the Vermont Agency of Transportation Standard Specifications to reflect the use of Portland cement as a replacement for pozzolan or pumicite.

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Standard Specifications for Highway and Bridge Construction

March, 1976

Section 707 - Joint Materials

707.04 MORTAR, TYPE IV. Mortar, Type IV, is generally used when a non-shrinking cement mortar is required.

The mortar shall be composed of 1 part cement and 1 part sand and mixed with sufficient water to form a plastic composition.

To produce a non-shrinking cement mortar, aluminum powder shall be added to the mix and proportioned as follows:

From 2 to 4 grams of the superfine unpolished variety of aluminum powder (about 1 or 2 teaspoons) shall be added for each sack of cement used in the mortar. The exact amount of aluminum powder shall be designated by the Engineer. The dosage per batch of mortar shall be carefully weighed. A number of weighings may be made in the laboratory and doses placed in glass vials for convenient use in the mix. The aluminum powder shall be blended with pozzolan or pumicite in the proportion of 1 part aluminum powder to 50 parts pozzolan or pumicite by weight. The blend shall be thoroughly mixed with the cement and sand before water is added to the batch, as it has a tendency to float on water. The amount of the blend used shall vary from 4½ ounces per sack of cement for a placing temperature of 70° F. to 7 ounces per sack of cement for a placing temperature of 40° F. After all ingredients are added, the batch shall be mixed for 3 minutes. Batches of mortar shall be placed within 45 minutes after mixing as the action of the aluminum powder becomes very weak after this time and it shall not be retempered or used after it has begun to set.

The cement, sand and water shall meet the following requirements:

- (a) Cement. Cement shall conform to the requirements of Portland Cement, subsection 701.01.
- (b) Sand. Sand shall conform to the requirements of Sand for Cement Mortar, subsection 704.19.
- (c) Water. Water shall conform to the requirements of Water, subsection 745.01.

Upon request, the Department will furnish a list of products or additives that are considered satisfactory to use for a non-shrinking cement mortar in lieu of that specified.

Products not on the Department's approved list, that meet the specifications, shall be certified by a Type A Certification in accordance with Subsection 700.02.

AGENCY OF TRANSPORTATION

OFFICE MEMORANDUM

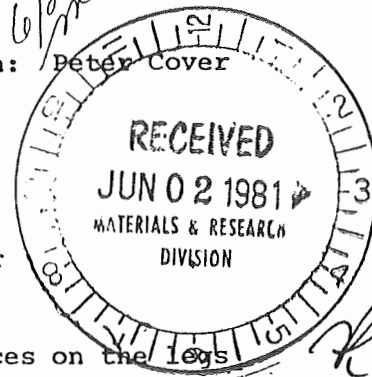
*To Peter Cover
J. a. B. 6/2/81
Don B. 6/2/81*

TO: R.F. Nicholson, Materials & Research Engineer Attn: Peter Cover

FROM: W.M. Smith, Structures Engineer *W.M. Smith*

DATE: June 2, 1981

SUBJECT: Waterford I 93-1(3) Cont. 1, Br. 1 Type IV Mortar



Type IV Mortar is to be used under the bearing devices on the legs of the steel rigid frame. For our information, we would like to know the compressive strength of this mortar.

Would you conduct the necessary tests, according to applicable AASHTO standards, to determine its strength. —

It is anticipated the frame will be erected in August 1981.

WMS/kg

c.c. Files
R.S. Haupt

Make place follows

AGENCY OF TRANSPORTATION

OFFICE MEMORANDUM

TO: W. M. Smith, P.E., Structures Engineer

FROM: P. A. Cover, P.E., Structural Concrete Engineer via R. F. Nicholson, P.E.,
Materials & Research Engineer

DATE: July 2, 1981

SUBJECT: Waterford-St. Johnsbury I 93-1 (3) C/1 Br. 1
Type IV Mortar

Testing of a Standard Type IV Mortar with Venus Multi-Leaf Aluminum No. 195 admixture was carried out in August 1974 by the Materials and Research Division and is documented on page 26 of Report No. 74-5. Even though the mixture tested was in a flowable consistency, the data indicates an impressive strength capability. It is my opinion that mortar strengths over 3500 psi could be obtained under field conditions only if all the materials are preweighed, and a maximum w/c ratio of 0.5 is strictly adhered to. Joe Talbot has confirmed that the materials will be preweighed and machine-mixed. We both agreed that it would be a good idea to cast 2x2 cubes at the project site to monitor strength gain. The cube specimens should be cast in a "restrained" condition by clamping a glass or steel plate over the top of the mold. The curing regime should be the same as that used for a field cured specimen.

With respect to preparing the mixture, page 8 of Report 74-5 has some useful information. Also, because it is important to use the good volume change properties of the mixture, I recommend that only as much mortar as can be used in one half hour, should be prepared at any one time.

A copy of Report 74-5 is attached for your information.

RFN/PAC/msd

Attachment

cc: RFN/Lab File
Resident Engineer Talbot
Concrete Chrono File
Central Files

AGENCY OF TRANSPORTATION

TO: J. L. Talbot, R.E. via J. R. Phalen, Construction Engineer

FROM: ^{WLM} W. L. Meyer, Technician C via ^{RFN} R. F. Nicholson, P.E., Materials & Research Engineer

DATE: August 28, 1981

SUBJECT: Waterford-St. Johnsbury I 93-1 (3) C/1
Mortar, Type IV (Non-shrinking cement mortar)

Following is the mix design for Mortar, Type IV, using aggregate and cement from the Lawrence Sangravco, St. Johnsbury plant.

Fine Aggregate - Lawrence Sangravco, Guildhall, Vt.	94 lbs. (dry)
Cement - Type II - Glens Falls Portland Cement Co. Glens Falls, N.Y.	94 lbs.
Aluminum Powder - Venus MultiLeaf Aluminum No. 195	3 grams
Water/Cement Ratio	.33 Maximum

The mix design is for a one bag batch and should yield approximately 1 1/2 ft³ of mortar when mixed. Section 707.04 MORTAR, TYPE IV of the Standard Specifications outlines the mixing procedures which must be followed when this material is used in the field.

RFN/WLM/msd
cc: RFN/Lab File
Concrete Chrono File
Central Files

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISIONPRODUCT EVALUATIONWork Plan No. 81-C-16Product Venus Multi-Leaf Aluminum No. 195Manufacturer U.S. Bronze PowderDistributor or
Representative N/AEvaluation Requested By W. M. Smith, Structures Eng. Date June 2, 1981Date Evaluation Required N/A Date Product Information Received N/ADate and Quantity of Samples Received N/A

Purpose of Evaluation To report the results of laboratory and field tests on Venus Multi-Leaf Aluminum No. 195 used for a Type IV Non-shrinking cement mortar for Waterford-St. Johnsbury I 93-1 (3) C/1, on the I 93 over Route 18 bridges. The results will add to the data included in the report, "Non-Shrinking Cement Mortar & Grout Evaluation Report". Report 74-5, Aug. 1, 1974; Revised - Dec. 17, 1976.

Proposed Tests The Laboratory results will include:

1. Unit Weight
2. Compressive Strength of 2" cubes and 4"x8" cylinders at 1, 3, 7 and 28 days.

The Field results will include:

1. Compressive strength of 2" cubes at 7 & 28 days

Proposal Discussed With R. Frascoia Projected Manpower Requirements 2 daysEvaluation To Be Conducted By Structural Concrete SubdivisionProposed Starting Date Sept. 23, 1981 Estimated Completion Date Oct. 7, 1981Approval/Disapproval by Materials & Research Engineer R.F. Nicholson 9/25/81

Comments by Materials & Research Engineer _____