

Investigation of Water Reducing Admixtures

AASHTO M-194 Type A

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TABLE OF CONTENTS

	<u>Page No.</u>
Abstract	1
Introduction	2
Materials	3
Procedures	5
Results	6
Summary	7
Conclusions & Recommendations	8

## ABSTRACT

This study was undertaken to evaluate the effects of water reducers when tested at a cement content of 660 lbs/c.y., the minimum cement content allowed in our Class A concrete, and to evaluate their compliance with the AASHTO M-194 specification for a Type A, water reducing admixture.

AASHTO M-194 allows the testing of water reducing admixtures at the cement content and gradation limits used in a specific design or at a cement content of  $517 \pm 4.7$  lbs/c.y.. The grading of aggregates when using the  $517 \pm 4.7$  lbs/c.y. cement content is spelled out in the specifications and would differ from the gradation used in our Class A concrete.

Test results indicate that water reducing admixtures do increase compressive strengths and do reduce the amount of water required for the desired slump, but may not by the same amount as certified by the manufacturers at the  $517 \pm 4.7$  lbs/c.y. cement content.

## INTRODUCTION

This series of tests on water reducing admixtures was conducted to determine their compliance with the 1976 Vermont Department of Highways Specifications. The admixture brands tested represent those commonly available in Vermont to the ready-mix industry as well as new products.

The specifications state that water reducing admixtures shall conform to the requirements of AASHTO M-194, Type A, for water content, time of setting, and 3-Day, 7-Day, and 28-Day compressive strengths.

The effect of water reducers on concrete, with a cement content of 660 lbs/c.y., our minimum for Class A concrete, was determined in order that proper mix designs incorporating their use can be made.

MATERIALS

The Class A (660 lbs/c.y.) concrete used in this investigation was proportioned to meet the requirements of Item 501 Structural Concrete - 1976 Standard Specifications for Highways and Bridges, Vermont Department of Highways. All batches contained the same quantities of coarse and fine aggregate and cement. Aggregate saturated surface dry weights were; 3/4 stone, 1645 lbs., sand, 1350 lbs.

A. Cement

The cement used in this test series was Type I as furnished by Glens Falls Portland Cement Company, Glens Falls, N.Y.

B. Aggregates

The aggregates used in this test series were as follows:

1. Coarse Aggregate

Lawrence Sangravco-Guildhall, Vermont

Gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>	<u>Specification Requirements</u>
1"	100	100
3/4"	97	90-100
3/8"	35	20- 55
#4	5	0- 10
#8	3	0- 5
Thin and Elongated Piece Count	1%	10% Maximum
Fractured Face Count	84%	50% Minimum

2. Fine Aggregate

Lawrence Sangravco-Guildhall, Vermont

Gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>	<u>Specification Requirements</u>
3/8"	100	100
#4	100	95-100
#8	94	-

<u>Sieve Size</u>	<u>Percent Passing</u>	<u>Specification Requirements</u>
#16	66	50- 80
#30	35	25- 60
#50	16	10- 30
#100	6	2- 10
Fineness Modulus 2.83		2.60-3.10
Color Plate -1		2 Maximum

C. Admixtures

The admixtures used in this test series were as follows:

1. Air Entraining Admixture:

(a) NVX - Hercules Powder Co.-Wilmington, Delaware

2. Water Reducing Admixtures

Application Rate

- |   |            |
|---|------------|
| (a) Pozzoloth 122N - Master Builders, Cleveland, Ohio                                 | 4 oz/sk    |
| (b) Pozzoloth 200N - " " " "  | 4 oz/sk    |
| (c) Plastocrete 160 - Sika Chemical Corp., Lyndhurst,<br>New Jersey                   | 3 oz/sk    |
| (d) FX-32RA - Fox Industries, Inc., Baltimore, Maryland                               | .75 lbs/sk |
| (e) WRDA Hycol - Construction Products Division,<br>W. R. Grace & Co., Cambridge, Ma. | 3 oz/cwt   |

## PROCEDURES

All concrete used in this investigation was blended in a Sears  $1\frac{1}{2}$  cu. ft. mixer following requirements outlined in AASHTO T-126. After the concrete was removed from the mixer the following tests were performed; air content, unit weight, yield, slump, temperature, and time of setting by penetration resistance. Three compressive strength specimens per batch were cast for testing at ages of 3 days, 7 days, and 28 days and net water content was determined.

Six batches of reference concrete were prepared. In addition, three batches of concrete containing the admixture were prepared for each admixture tested. The average of the test results obtained from the reference batches was then compared to the average of the test results of batches containing the admixture in order to determine the effect of the water reducing admixture tested.

The procedures used in mixing throughout this investigation followed as closely as possible that which is required in AASHTO T-126 as modified in AASHTO M-194 Section 12, Paragraph 12-1.

Strict laboratory procedures were emphasized in an attempt to control slump within the  $2\frac{1}{2} \pm \frac{1}{2}$ " limit and control the percent of air within the 3.5 - 7.0 percent range.

RESULTS

Following Are Listed The Average Results of Tests Performed In the Investigation:

Type of Test	Reference	Pozzolith 122N	Pozzolith 200N	Plastocrete 160	FX-32RA	WRDA Hycol	AASHTO Specifications
Slump (inches)	3.0	2.3	2.3	2.5	2.6	2.4	2-3
Air Content (percent) Pressure	5.2	5.0	4.9	5.4	6.4	5.3	3.5-7.0
Chace	5.5	5.3	5.3	5.3	5.7	5.9	--
Mix Temperature (°F)	75	73	78	77	73	73	73+3
Density (pcf)	144.27	144.93	145.56	144.25	143.15	143.89	--
Mix Yield (cu. ft.)	27.29	27.11	27.00	27.26	27.17	27.26	--
Water Cement Ratio	.430	.416	.416	.423	.356	.408	
Relative Water Content (lbs./cy)	284	274	274	279	235	269	
Percent of Reference		96.5	96.5	98.2	82.7	94.7	95 maximum
Compressive Strength (psi) 3 days	3003	3360	3572	3251	3997	3189	
Percent of Reference		112	119	108	133	106	110 minimum
7 days	3366	3825	4026	3655	4072	3445	
Percent of Reference		114	120	109	121	102	110 minimum
28 days	3988	4492	4739	4132	4580	4132	
Percent of Reference		113	119	104	115	104	110 minimum
Time of Setting (hours:min.)							
Initial Set	5:19	6:26	6:50	5:53	6:41	6:13	
Deviation from Reference		+1:07	+1:31	+0:34	+1:22	+0:54	-1 hr. to + 1 hr. 30 min.
Final Set	6:47	7:44	7:55	7:15	8:05	7:49	
Deviation from Reference		+0:57	+1:08	+0:28	+1:18	+1:02	-1 hr. to + 1 hr. 30 min.



## SUMMARY

1. Slump control for all concrete batches was held within prescribed limits.
2. Air content, tested in accordance with AASHTO T-152, was held within the specification range on all test batches, however, the air content of FX-32 RA was not within the limits of  $\pm 0.5$  percent of the reference concrete.
3. Mix temperatures on two of the products tested, Pozzolith 200N and Plastocrete 160, were  $2^{\circ}$  and  $1^{\circ}$  respectively above specification limits.
4. The maximum water content, expressed as a percent of the reference mix, was not obtained by three of the products tested, Pozzolith 122N, Pozzolith 200N, and Plastocrete 160.
5. The compressive strengths, expressed as a percent of the reference mixes, were not obtained by two of the products tested, Plastocrete 160 and WRDA Hycol. These products failed to obtain the required 10% strength increase at each of the test ages; 3, 7, and 28 days.
6. With the exception of Pozzolith 200N, which failed the test for initial set by one minute, all of the products tested met the specification requirements for both initial and final time of setting.

## CONCLUSIONS & RECOMMENDATIONS

1. Certifications by the manufacturers of the products that were tested state that their products meet AASHTO specifications. These specifications allow the testing of these admixtures at a cement content of  $517 \pm 4.7$  lbs. of cement per cubic yard of concrete or at a cement content specified for use in the work.
2. Our test results show that only one product, FX-32 RA conformed to the specification when tested at a cement content of 660 lbs/c.y.. The fact that each of the other products tested failed to meet the specifications at the cement content specified for use in the work does not discredit the certifications made by the manufacturers.
3. Our test results show that some products exceeded the strength requirements but failed to obtain the necessary percent of water reduction at the 660 lbs/c.y. cement content. Although the percent of water reduction was not as high as we would like to see, the advantage of an increase in strength can not be ignored.
4. Several articles have indicated that the percent of water reduction obtained from water reducing admixtures is a function of the components of a concrete mix. The brand, the type and the quantity of cement are a few of these factors. In order to determine which products are compatible with a particular mix design, the products proposed for use should be tested in that particular mix design. Each of the products proposed for use in this State should first be tested at a cement content of  $517 \pm 4.7$  lbs. in accordance with AASHTO M-194. Those products that comply with the specifications should then be tested for compatibility with the mix design proposed for the work. Only those products that prove to be beneficial should be approved for the particular design. The proportions of each mix design are based upon the characteristics of the aggregates used and the strength obtainable with those aggregates. With this knowledge and the test results of the proposed water reducer, each mix design can be analyzed for compliance with the desired strength.

5. FX-32 RA, the only product that met the specifications at the 660 lbs/c.y. cement content, is no longer available from the manufacturer. New products have been developed by Fox Industries to replace the product tested. A program of testing the new products, catalytic agents and so called super water reducers will be initiated.

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