

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS DIVISION

LAWRENCE SANGRAVCO INC.
ST. JOHNSBURY, VERMONT
TRIAL MIXES FOR CLASS A CONCRETE

REPORT 78-6
FEBRUARY 1978

REPORTING ON WORK PLAN NO. 77-C-34

R.E.W. Crisman, Acting Commissioner
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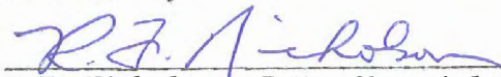
Prepared By

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Materials Division
Highway Department
Agency of Transportation
March 30, 1978

Reviewed By:


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

Date: March 30, 1978

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ABSTRACT

This investigation was initiated to determine the potential strength of a mix design for Class A Concrete using various water reducing and retarding admixtures with material from Lawrence Sangravco Inc., St. Johnsbury, Vermont.

Results of this investigation were widespread and inconclusive. Because of the deviations obtained in these tests more results are needed in order to obtain a meaningful conclusion.

INTRODUCTION

Several water reducing admixtures and retarding admixtures are available to ready mixed concrete producers in Vermont for use in portland cement concrete. Generally, these admixtures are supplied by two manufacturers, either W.R. Grace & Co., Cambridge, Mass., or Master Builders, Cleveland, Ohio.

Class A concrete from Lawrence Sangravco, St. Johnsbury, Vermont was evaluated for compressive strength using three water reducing admixtures and three retarding admixtures. The desired 28 day compressive strength is 4875 psi. The minimum specified 28 day compressive strength is 4000 psi.

Six trial mixes using basically one mix design with aggregates supplied by Lawrence Sangravco Inc. were used in this investigation. The object was to determine if the basic mix design was adequate to produce concrete of the desired quality in order to assure that the specified strength of 4000 psi could be produced in a minimum of 9 out of 10 tests.

The results of the proposed trial mixes are intended to give a prediction as to the probable performance of the mix design.

MATERIALS

Following are listed the materials used in this investigation:

Coarse Aggregate:

3/4" Stone - Lawrence Sangravco, Guildhall, Vermont

Fine Aggregate:

Lawrence Sangravco, Guildhall, Vermont

Cement:

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

Admixtures:

Air entraining:

Darex AEA - Construction Products Division, W.R. Grace & Co.
Cambridge, Mass.

Water Reducing:

Pozzolith 122N - Master Builders, Cleveland, Ohio
WRDA w/Hycol - Construction Products Division
W.R. Grace & Co., Cambridge, Mass.
WRDA - Construction Products Division
W.R. Grace & Co., Cambridge, Mass.

Retarding:

Pozzolith 100XR - Master Builders, Cleveland, Ohio
Daratard HC - Construction Products Division
W.R. Grace & Co. Cambridge, Mass.
Daratard 17 - Construction Products Division
W.R. Grace & Co. Cambridge, Mass.

PROCEDURES

The Class A (660 Lbs/cy cement) concrete was designed following the procedures outlined in ACI 211.1 "Recommended Practice for Selecting Proportions for Normal Weight Concrete".

Six batches of concrete were prepared, one batch for each admixture investigated. All concrete was mixed in a Lancaster mixer with temperatures maintained at $73^{\circ}\text{F} \pm 3^{\circ}\text{F}$.

After mixing, the concrete was tested for air content, slump, unit weight and yield, and 7, 14 and 28 day compressive strength.

MATERIALS DIVISION - STRUCTURAL CONCRETE SUBDIVISION Date 6/6/77MIX DESIGN SHEET - STRUCTURAL CONCRETE ITEM # 501.20 CONCRETE CLASS AReady Mix Supplier: Lawrence Sangravco Inc.

Aggregate Supplier:	Specific Gravity	Dry Rodded Unit Weight	Absorption
<u>3/4"</u> Stone <u>Lawrence Guildhall</u>	<u>2.78</u>	<u>98.52</u>	<u>1.1</u>
<u>"</u> Stone			
Blend: <u>1-1/2"</u> & <u>3/4"</u>			
Sand <u>Lawrence Guildhall</u>	<u>2.64</u>	<u>F.M. 2.80</u>	<u>1.6</u>

Cement 660 Lbs./Cu.Yd.
 Water 35 Gals./Cu.Yd.
 Air 6 Percent

VOLUME OF DRY RODDED COARSE AGGREGATE
PER UNIT VOLUME OF CONCRETE

Maximum size Aggregate	Sand F.M.					
	2.60	2.70	2.80	2.90	3.00	3.10
<u>3/4"</u>	<u>0.64</u>	<u>0.63</u>	<u>0.62</u>	<u>0.61</u>	<u>0.60</u>	<u>0.59</u>
<u>1-1/2"</u>	<u>0.73</u>	<u>0.72</u>	<u>0.71</u>	<u>0.70</u>	<u>0.69</u>	<u>0.68</u>

$$\frac{98.52}{\text{(Dry Rodded Unit Weight)}} \times \frac{.62}{\text{(Unit Volume)}} = \frac{60.78}{\text{}} \times 27 = \frac{1640}{\text{}} \text{ Lbs./CY Coarse Aggregate}$$

1. Volume of Water (Gals/CY) $\frac{35}{7.48} = \frac{4.679}{\text{}} \text{ Cu. Ft.}$
2. Solid Volume of Cement (Lbs./CY) $\frac{660}{196.56} = \frac{3.358}{\text{}} \text{ Cu. Ft.}$
3. Volume of Entrained Air $\frac{6}{\text{}} \times 27 = \frac{1.620}{\text{}} \text{ Cu. Ft.}$
4. Solid Volume of Coarse Aggregate $\frac{\text{(Lbs./CY 1640)}}{\text{(SpGr) } 2.78} \times 62.4 = \frac{9.454}{\text{}} \text{ Cu. Ft.}$
5. Total Solid Volume of Ingredients Except Sand $\frac{19.111}{\text{}} \text{ Cu. Ft.}$
6. Solid Volume of Sand Required $27.00 - 19.111 \text{ Cu.Ft. (Line 5)} = \frac{7.889}{\text{}} \text{ Cu. Ft.}$
7. Required Weight of Sand: $\frac{\text{(Solid Volume) } 7.889}{\text{}} \times \frac{\text{(SpGr) } 2.64}{\text{}} \times 62.4 = \frac{1300}{\text{}} \text{ Lbs./Cu.Yd.}$
8. Ratio of Sand to Total Agg. $\text{Line 6} \div (\text{Line 6} + \text{Line 4}) = \frac{45.5}{\text{}} \% \text{ by Vol.}$

SUMMARY OF QUANTITIES/CU. YD. (DRY WEIGHTS)

	Trial # 1	Trial # 2	Trial # 3	
<u>3/4"</u> Stone	<u>1640</u>	<u>1640</u>	<u>1640</u>	Lbs.
<u>"</u> Stone				Lbs.
Sand	<u>1300</u>	<u>1300</u>	<u>1300</u>	Lbs.
Cement	<u>660</u>	<u>660</u>	<u>660</u>	Lbs.
Water	<u>35</u>	<u>35</u>	<u>35</u>	Gals.

MATERIALS DIVISION - STRUCTURAL CONCRETE SUBDIVISION Date 6-6-77MIX DESIGN SHEET - STRUCTURAL CONCRETE ITEM # 501.20 CONCRETE CLASS AReady Mix Supplier: Lawrence Sangravco Inc.

Aggregate Supplier:	Specific Gravity	Dry Rodded Unit Weight	Absorption
<u>3/4" Stone</u> <u>Lawrence Guildhall</u>	<u>2.78</u>	<u>98.52</u>	<u>1.1</u>
<u>" Stone</u>			
<u>Blend: 1-1/2" & 3/4"</u>			
<u>Sand</u> <u>Lawrence Guildhall</u>	<u>2.64</u>	<u>F.M. 2.80</u>	<u>1.6</u>

Cement 660 Lbs./Cu.Yd.Water 35 Gals./Cu.Yd.Air 6 PercentVOLUME OF DRY RODDED COARSE AGGREGATE
PER UNIT VOLUME OF CONCRETE

Maximum size Aggregate	Sand F.M.					
	2.60	2.70	2.80	2.90	3.00	3.10
<u>3/4"</u>	<u>0.64</u>	<u>0.63</u>	<u>0.62</u>	<u>0.61</u>	<u>0.60</u>	<u>0.59</u>
<u>1-1/2"</u>	<u>0.73</u>	<u>0.72</u>	<u>0.71</u>	<u>0.70</u>	<u>0.69</u>	<u>0.68</u>

$$\frac{98.52}{(\text{Dry Rodded Unit Weight})} \times \frac{.62}{(\text{Unit Volume})} = \frac{60.78}{\text{X } 27} = \frac{1640}{\text{Lbs./CY Coarse Aggregate}}$$

1. Volume of Water (Gals./CY) $\frac{35}{7.48} = 4.679$ Cu. Ft.
2. Solid Volume of Cement (Lbs./CY) $\frac{660}{196.56} = 3.358$ Cu. Ft.
3. Volume of Entrained Air $\frac{6}{\text{X } 27} = 1.620$ Cu. Ft.
4. Solid Volume of Coarse Aggregate $\frac{(\text{Lbs./CY } 1640)}{(\text{SpGr } 2.78) \times 62.4} = 9.454$ Cu. Ft.
5. Total Solid Volume of Ingredients Except Sand 19.111 Cu. Ft.
6. Solid Volume of Sand Required $27.00 - 19.111 \text{ Cu.Ft. (Line 5)} = 7.889$ Cu. Ft.
7. Required Weight of Sand:
 $\frac{(\text{Solid Volume}) 7.889}{\text{X } (\text{SpGr } 2.64)} \times 62.4 = 1300$ Lbs./Cu.Yd.
8. Ratio of Sand to Total Agg. $\text{Line 6} \div (\text{Line 6} + \text{Line 4}) = 45.5$ % by Vol.

SUMMARY OF QUANTITIES/CU. YD. (DRY WEIGHTS)

	Trial # 4	Trial # 5	Trial # 6	
<u>3/4" Stone</u>	<u>1640</u>	<u>1640</u>	<u>1640</u>	Lbs.
<u>" Stone</u>	<u>-</u>	<u>-</u>	<u>-</u>	Lbs.
<u>Sand</u>	<u>1300</u>	<u>1300</u>	<u>1300</u>	Lbs.
<u>Cement</u>	<u>660</u>	<u>660</u>	<u>660</u>	Lbs.
<u>Water</u>	<u>35</u>	<u>35</u>	<u>35</u>	Gals.

RESULTS OF TRIAL BATCHES ..

Air Admixture used: DAREX AEA

Manufactured by: W. R. Grace, Cambridge Massachusetts

Other Admixtures used: Pozzolith 122N

Manufactured by: Master Builders - Cleveland, Ohio

	TRIAL # 1	TRIAL #	TRIAL #
Air Admixture Dosage	<u>6 oz/c.y.</u>	<u> </u>	<u> </u>
Other Admixture Dosage	<u>5 oz/cwt</u>	<u> </u>	<u> </u>
% Air	<u>5.5</u>	<u> </u>	<u> </u>
Slump	<u>2 1/2</u>	<u> </u>	<u> </u>
Unit Weight	<u>141.85</u>	<u> </u>	<u> </u>
Yield	<u>27.63</u>	<u> </u>	<u> </u>
W/C Ratio	<u>0.43</u>	<u> </u>	<u> </u>

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	<u>3148</u>	<u> </u>	<u> </u>
14 Days	<u>4041</u>	<u> </u>	<u> </u>
28 Days	<u>4271</u>	<u> </u>	<u> </u>
___ Days	<u> </u>	<u> </u>	<u> </u>

Remarks: The strengths expected from this mix design were not obtained. The
unit weight of 141.85 was lower than the design unit weight of 145.59. Perhaps
the air content was higher than the test results indicated. This mix design
should be evaluated with a closer unit weight and closer yield.

RESULTS OF TRIAL BATCHES

Air Admixture used: DAREX AEA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

Other Admixtures used: WRDA Hycol

Manufactured by: W.R. Grace, Cambridge, Massachusetts

	TRIAL # 2	TRIAL #	TRIAL #
Air Admixture Dosage	<u>4 oz/c.y.</u>	<u></u>	<u></u>
Other Admixture Dosage	<u>5 oz/cwt</u>	<u></u>	<u></u>
% Air	<u>5.3</u>	<u></u>	<u></u>
Slump	<u>2 1/2</u>	<u></u>	<u></u>
Unit Weight	<u>143.17</u>	<u></u>	<u></u>
Yield	<u>27.35</u>	<u></u>	<u></u>
W/C Ratio	<u>0.41</u>	<u></u>	<u></u>

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	<u>3316</u>	<u></u>	<u></u>
14 Days	<u>3970</u>	<u></u>	<u></u>
28 Days	<u>4669</u>	<u></u>	<u></u>
<u> </u> Days	<u></u>	<u></u>	<u></u>

Remarks: The strengths obtained for this mix design were slightly lower
than desired, although, within a range that is expected. The unit
weight of this mix was on the low side. This mix design should be
evaluated for performance. No changes are recommended at this time.

RESULTS OF TRIAL BATCHES

Air Admixture used: DAREX AEA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

Other Admixtures used: WRDA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

	TRIAL # 3	TRIAL #	TRIAL #
Air Admixture Dosage	<u>2 oz/c.y.</u>	<u></u>	<u></u>
Other Admixture Dosage	<u>5 oz/cwt</u>	<u></u>	<u></u>
% Air	<u>4.6</u>	<u></u>	<u></u>
Slump	<u>2 1/2</u>	<u></u>	<u></u>
Unit Weight	<u>144.78</u>	<u></u>	<u></u>
Yield	<u>27.00</u>	<u></u>	<u></u>
W/C Ratio	<u>.41</u>	<u></u>	<u></u>

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	<u>3413</u>	<u></u>	<u></u>
14 Days	<u>4430</u>	<u></u>	<u></u>
28 Days	<u>5101</u>	<u></u>	<u></u>
___ Days	<u></u>	<u></u>	<u></u>

Remarks: This mix design produced very high strengths. The percent of air
was lower than the design aim of 6% and probably accounted for slightly
higher strength than normally would have been obtained at 6% air. More
test results should be monitored for evaluation. The dosage of Darex AEA
should be adjusted to compensate for the low air.

RESULTS OF TRIAL BATCHES

Air Admixture used: DAREX AEA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

Other Admixtures used: Pozzolith 100XR

Manufactured by: Master Builders, Cleveland, Ohio

	TRIAL # 4	TRIAL #	TRIAL #
Air Admixture Dosage	<u>5.5 oz/c.y.</u>	<u> </u>	<u> </u>
Other Admixture Dosage	<u>5 oz/cwt</u>	<u> </u>	<u> </u>
% Air	<u>5.0</u>	<u> </u>	<u> </u>
Slump	<u>2 1/2</u>	<u> </u>	<u> </u>
Unit Weight	<u>143.29</u>	<u> </u>	<u> </u>
Yield	<u>27.30</u>	<u> </u>	<u> </u>
W/C Ratio	<u>.41</u>	<u> </u>	<u> </u>

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	3546		
14 Days	4156		
28 Days	5376		
Days			

Remarks: This mix design produced very high strength. The percent of air was on the low side of the design aim, but within the acceptable limits of 6 ± 1 %. Further test results should be monitored for this design. An increase in the dosage of Darex AEA may be required.

RESULTS OF TRIAL BATCHES

Air Admixture used: DAREX AEA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

Other Admixtures used: Daratard HC

Manufactured by: W.R. Grace, Cambridge, Massachusetts

	TRIAL # 5	TRIAL #	TRIAL #
Air Admixture Dosage	5.5 oz/c.y.		
Other Admixture Dosage	6 oz/cwt		
% Air	5.4		
Slump	3 1/2		
Unit Weight	144.66		
Yield	27.04		
W/C Ratio	.41		

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	3210		
14 Days	3767		
28 Days	4209		
Days			

Remarks: The strengths expected from this mix design were not obtained. The slump was higher than Class A requirements for bridge deck construction but within the limits of 2 - 4" for other applications. Further monitoring of test results is recommended. No apparent reason can be determined for the relatively low strengths obtained.

RESULTS OF TRIAL BATCHES

Air Admixture used: DAREX AEA

Manufactured by: W.R. Grace, Cambridge, Massachusetts

Other Admixtures used: Daratard 17

Manufactured by: W.R. Grace, Cambridge, Massachusetts

	TRIAL # <u>6</u>	TRIAL #	TRIAL #
Air Admixture Dosage	<u>5.5</u>		
Other Admixture Dosage	<u>6 oz/cwt</u>		
% Air	<u>5.2</u>		
Slump	<u>2 1/4</u>		
Unit Weight	<u>143.49</u>		
Yield	<u>27.19</u>		
W/C Ratio	<u>.40</u>		

Average
Compressive Strengths - Standard Cured 6" x 12" Cylinders

7 Days	<u>3413</u>		
14 Days	<u>4554</u>		
28 Days	<u>5014</u>		
___ Days			

Remarks: This mix design produced very high strengths. The percent
of air was on the low side of the design aim, but within the
acceptable limits of 6 + 1%. Further test results should be
monitored for this design. An increase in the dosage of Darex
AEA may be required.

SUMMARY OF TEST RESULTS

Trial Mix No.	1	2	3	4	5	6
	Pozzolith			Pozzolith		
Admixture	122N	WRDA HYCOL	WRDA	100XR	Daratard HC	Daratard 17
Dosage	5 oz/cwt	5 oz/cwt	14 oz/cwt	5 oz/cwt	6 oz/cwt	6 oz/cwt
Admixture	Darex AEA	Darex AEA	Darex AEA	Darex AEA	Darex AEA	Darex AEA
Dosage	6 oz/c.y.	4 oz/c.y.	2 oz/c.y.	5.5 oz/c.y.	5.5 oz/c.y.	5.5 oz/c.y.
Percent Air	5.5	5.3	4.6	5.0	5.4	5.2
Slump	2 1/2	2 1/2	2 1/2	2 1/2	3 1/2	2 1/4
Unit Weight	141.85	143.17	144.78	143.29	144.66	143.49
Yield Ft. ³	27.64	27.35	27.00	27.30	27.04	27.19
W/C Ratio	0.43	0.41	0.41	0.41	0.41	0.40
Mix Temp. °F	73	73	74	73	73	74
<u>Compressive Strength PSI</u>						
7 Days Avg.	3148	3316	3413	3546	3210	3413
14 Days Avg.	4041	3970	4430	4156	3767	4554
28 Days Avg.	4271	4669	5101	5376	4209	5014

CONCLUSIONS

The purpose of the trial mixes was to determine if a mix design of 660 lbs/cy of type II cement was adequate to produce concrete of the desired quality when used with the materials available to Lawrence Sangravco Inc.

A compressive strength of 4875 psi was selected as a desired strength. This strength was selected after reviewing the history of the past performance of Class A Concrete produced by Lawrence Sangravco Inc.

The test results obtained from our trial mixes indicate that the 28 day compressive strengths varied considerably. Only trial mixes numbers 3, 4 and 6 obtained the desired strength of 4875 psi. Trial mixes numbers 1, 2 and 5 failed to obtain the desired strength, but did obtain strength in excess of the 4000 psi as specified for Class A Concrete.

The results of testing a single trial mix for evaluation are usually inconclusive. A series of test values are needed to predict, with any degree of accuracy, the strength ability of a particular design. The results of a single trial mix do however indicate whether or not a mix design is realistic. The mix design used in preparing these trial mixes does appear to be realistic but more information on test results will be required before a final assessment can be made.

RECOMMENDATIONS

The trial mixes using various water reducing and retarding admixtures will require more study in order to confirm the results we obtained. The ability of the design appears to be adequate when controlled properly with the correct admixtures.

Trial mix numbers 1,2 and 5 appear to warrant the closest attention. Should test results indicate that these mixes fail to produce concrete of the desired quality, changes should be initiated to introduce trial mix number 3, 4 or 6 depending upon the intended use of the concrete.

When results of field tests become available an evaluation of the results should be included with this report in the form of an addendum.

Materials Division - Structural Concrete Subdivision

PRODUCT EVALUATION WORK PLAN

Number 77-C-34

Product Trial Mixes-Lawrence Sangravco - St. Johnsbury and Guildhall, VT Class A Concrete

Manufacturer (Aggregate) Lawrence Sangravco Guildhall, VT
Distributor or N/A
Representative

Evaluation Requested By In House Date N/A

Date Information Required N/A

Date Product Data & Application Instructions Received N/A

Date Samples Received May 17, 1977

Sample Quantity N/A Were sufficient samples received yes

Purpose of Evaluation

To evaluate our mix design for Class A concrete when used with various water reducing
and retarding Admixtures to determine if concrete of the desired quality can be
produced. Desired 28 day compressive strength 4875 psi. *See additional sheet for
Proposed Tests (Attach extra sheet if necessary) admixture data.

1. One batch for each Admixture used.
Air Content
Slump
Temperature
Unit Weight and Yield
7, 14, and 28 day compressive strength
Using 6" x 12" cylinders

Proposal Discussed with following Sub-divisions Research & Development Compliance
Testing
Projected Manpower Requirements 11 Mandays including report

Evaluation to be Conducted by Structural Concrete Subdivision

Proposed Starting Date June 6, 1977 Estimated Completion Date July 29, 1977

Approval/Disapproval by Materials Engineer R. J. Nicholson 6/7/77

Comments by Materials Engineer _____

<u>Manufacturer</u>	<u>Product Name</u>	<u>Addition Rate</u>
<u>Water Reducing Admixtures</u>		
Master Builders Cleveland, OH	Pozzolith 122N	5 oz/cwt.
W. R. Grace & Co. Cambridge, MA	WRDA W/Hycol	5 oz/cwt.
W. R. Grace & Co. Cambridge, MA	WRDA	14 oz/cwt.

Retarding Admixtures

Master Builders Cleveland, OH	Pozzolith 100XR	5 oz/cwt.
W. R. Grace & Co. Cambridge, MA	Daratard HC	6 oz/cwt.
W. R. Grace & Co. Cambridge, MA	Daratard 17	6 oz/cwt.