LABORATORY EVALUATION OF DARACEM 100 HIGH RANGE WATER REDUCING ADMIXTURE AND HIGH RANGE WATER REDUCING AND RETARDING ADMIXTURE

REPORT 85-9
SEPT. 1985

Reporting on Work Plan 84-C-18

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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ABSTRACT

This evaluation was initiated to examine Daracem 100, a concrete admixture manufactured by W. R. Grace & Company, Cambridge, Massachusetts. The material is formulated by the manufacturer to perform as either a high range water reducing admixture, AASHTO M 194, Type F or a high range water reducing and retarding admixture, AASHTO M 194, Type G, depending upon addition rate.

The product complied with requirements of AASHTO M 194-84I, Chemical Admixtures for Concrete, for compressive strength, time of setting, water content and resistance to freezing and thawing as both a Type F and Type G admixture. Higher slump concrete for both addition rates was examined for the above properties and for rate of slump loss.

This report recommends that trial use of Daracem 100 be permitted in prestressed concrete or other precast applications where it's use can be closely monitored.

INTRODUCTION

The Structural Concrete Subdivision initiated this evaluation of Daracem 100 following a request for it's approval from the manufacturer, W. R. Grace & Company, Cambridge Massachusetts. Tests were conducted to determine if the material complied with requirements of AASHTO M 194, Chemical Admixtures for Concrete and to examine higher slump concrete containing the material.

The Daracem 100 is formulated to perform as either a high range water reducing admixture, AASHTO M 194, Type F, or a high range water reducing and retarding admixture, AASHTO M 194, Type G, depending upon addition rate. It is described by the manufacturer as an "aqueous solution of polymerized napthalene sulfonates and modified lignosulfonates".

Concrete containing the material was examined in the laboratory for compressive strength, water content, time of setting and resistance to freezing and thawing. Higher slump mixes were also examined for rate of slump loss. Two addition rates, recommended by the manufacturer, were used to study the product as an AASHTO M 194, Type F and Type G admixture.

MATERIALS

The materials used in this investigation are as follows:

A. Aggregates

1. Coarse Aggregate

   3/4 Inch Crushed Igneous Stone

   Cooley, Websterville, Vermont

TABLE 1

COARSE AGGREGATE TEST DATA

	3/4 Inch Crushed Igneous Stone Date Sampled 12-5-84	VAOT Specification Requirements
Sieve Size	% Passing	% Passing
1"	100	100
3/4"	94	90-100
3/8"	28	20-55
#4	4	0-10
#8	3	0-5
L.A. Abrasion, percent loss "B" Grading	34.2	50 Maximum
Thin & Elongated Pieces, percent	1	10 Maximum
Fractured Faces, percent	100	-

2. Fine Aggregate

A. G. Anderson, Highgate, Vermont

TABLE 2

FINE AGGREGATE TEST DATA

	Fine Aggregate Date Sampled 12-5-84	VAOT Specification Requirements
Sieve Size	% Passing	% Passing
3/8"	100	100
#4	98	95-100
#8	86	-
#16	67	60-80
#30	42	25-60
#50	19	10-30
#100	5	2-10
#200	1.1	-
Fineness Modulus	2.83	2.60-3.10
Organic Impurities, color	<1	2 Maximum

B. Cement

Type II

Glens Falls Portland Cement Company, Glens Falls, New York

C. Air Entraining Admixture

Daravair

W. R. Grace & Company, Cambridge, Massachusetts

D. High Range Water Reducing Admixture/High Range Water Reducing and Retarding Admixture

Daracem 100

W. R. Grace & Company, Cambridge, Massachusetts

PROCEDURES

The Class B concrete used in this investigation was prepared in the laboratory in a Sears 3½ cu.ft. mixer. The Daracem 100 was examined at two addition rates in order to determine compliance as both an AASHTO M 194 Type F and Type G admixture. Three batches of concrete were prepared with each addition rate of admixture for comparison with three batches of reference concrete. These batches contained 1.8 cu.ft. of concrete and were used to determine specification compliance. Two additional batches, one for each addition rate of admixture were prepared to examine higher slump concrete and rate of slump loss. These batches contained 3.0 cu.ft. of concrete.

Tests were performed on the fresh concrete to determine Slump (AASHTO T 119-82), Air Content (AASHTO T 152-84I), Unit Weight (AASHTO T 121-82) & Time of Setting (AASHTO T 197-82). Four 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) one from each batch at ages 1, 3, 7, and 28 days. The freeze-thaw specimens were moist cured for 14 days, after which they were subjected to 300 cycles of freezing and thawing (AASHTO T 161-83I) in a 3 percent NaCl solution.

The concrete used to examine higher slumps and rate of slump loss was mixed and tested in the same manner as the other batches. The rate of slump loss was determined by repeating the slump test at 15 minute intervals until testing was terminated.

Mix design quantities for all concretes are shown in Table 3.

TABLE 3

CLASS B CONCRETE MIX DESIGNS
BATCH QUANTITIES PER CUBIC YARD

		Test Concrete			
		AASHTO M 194 Type F		AASHTO M 194 Type G	
	Reference Concrete	Specification Compliance Concrete	Higher Slump Concrete	Specification Compliance Concrete	Higher Slump Concrete
*Coarse Aggregate, lbs	1629	1629	1629	1629	1629
*Fine Aggregate, lbs	1401	1488	1488	1488	1488
Cement, lbs	611	611	611	611	611
Air Entraining Admixture, oz	4.6-6.1	5.6-6.1	4.9	4.6-5.6	4.0
Daracem 100, oz	-	61	61	92	92

*Weights converted to saturated surface-dry condition.

RESULTS

Following are test results from the batches used to determine specification compliance of Daracem 100 as an AASHTO M 194, Type F and Type G admixture:

	Daracem 100 Concrete			
	Reference Concrete	AASHTO M 194-84I Type F	Type G	AASHTO M 194-84I
Slump, inches				
Batch 1	3	2 3/4	2 1/2	
Batch 2	3	2 1/4	2 3/4	
Batch 3	3 1/2	1 3/4	3	2½ ± ½ (1)
Average	3 1/4	2 1/4	2 3/4	
Air Content, percent				
Batch 1	4.9	5.9	6.0	
Batch 2	4.9	5.2	5.9	
Batch 3	5.9	5.0	5.2	5 - 7 (2)
Average	5.2	5.4	5.7	
Unit Weight, lbs/ft^3				
Batch 1	145.50	145.35	146.36	
Batch 2	145.50	146.94	146.60	
Batch 3	144.34	147.32	147.23	
Average	145.11	146.54	146.73	
Concrete Temp.,°F				
Batch 1	71	71	72	
Batch 2	71	71	71	
Batch 3	71	72	72	73 ± 3
Average	71	71	72	

(1) VAOT requirement for Class B concrete is 2 - 4 inches.

(2) VAOT requirement for Class B concrete is 4 - 6 percent. AASHTO M 194-84I also requires the difference between the air content of the reference concrete and that of the concrete containing the admixture under test shall not exceed 0.5 percent.

	Reference Concrete	Daracem 100 Concrete AASHTO M 194-84I Type F	Type G	AASHTO M 194-84I
Water Content, lbs/yd^3				
Batch 1	259	229	212	
Batch 2	260	230	214	
Batch 3	259	228	213	
Average	259	229	213	
Percent of Reference		88	82	88 Maximum
Time of Setting, Hrs:Min				
Initial Set		(1)	(1)	
Batch 1	4:48	5:51	6:39	
Batch 2	5:03	5:51	7:15	
Batch 3	5:33	6:00	7:30	
Average	5:08	5:54	7:08	
Deviation from Reference				
Type F		0:46 (later)		Not more than 1:00 earlier nor 1:30 later.
Type G			2:00 (later)	At least 1:00 later, not more than 3:30 later.
Final Set				
Batch 1	6:35	7:12	8:12	
Batch 2	6:36	7:21	8:57	
Batch 3	6:54	7:24	9:03	
Average	6:42	7:19	8:44	
Deviation from Reference				
Type F		0:37 (later)		Not more than 1:00 earlier nor 1:30 later.
Type G			2:02 (later)	Not more than 3:30 later.

(1) During performance of initial time of set tests, when the one square inch needle was used, it was noted that a film or crust had formed on the surface of the specimens containing Daracem 100. This film was sufficiently strong to cause a depression or sag in the top of the specimen prior to the needle penetrating the surface.

		Daracem 100 Concrete		
	Reference Concrete	AASHTO M 194-84I Type F	Type G	AASHTO M 194-84I
Compressive Strength, psi-1 day				
Batch 1	——	3307	3935	
Batch 2	1910	3369	3908	
Batch 3	2334	3555	4085	
Average	2122	3410	3976	
Percent of Reference				
Type F		161		140 Minimum
Type G			187	125 Minimum
Compressive Strength, psi-3 days				
Batch 1	3746	4801	5827	
Batch 2	3457	4925	5632	
Batch 3	3501	5111	5739	
Average	3568	4946	5733	
Percent of Reference		139	161	125 Minimum
Compressive Strength, psi-7 days				
Batch 1	4262	5199	6720	
Batch 2	4094	5544	6561	
Batch 3	4103	5774	6862	
Average	4153	5506	6714	
Percent of Reference		133	162	115 Minimum
Compressive Strength, psi-28 days				
Batch 1	6013	7181	8223	
Batch 2	5544	6898	8205	
Batch 3	5668	7393	8311	
Average	5742	7157	8246	
Percent of Reference		125	144	110 Minimum

	Reference Concrete	Daracem 100 Concrete AASTHO M 194-84I Type F	Type G	AASHTO M 194-84I
Resistance to Freezing and Thawing-300 cycles				
Durability Factor				
Batch 1	95.8	97.9	98.6	
Batch 2	97.2	100.0	97.2	
Batch 3	97.9	98.6	96.5	
Average	97.0	98.8	97.4	
Relative Durability Factor		101.9	100.4	80 Minimum
Weight Loss, percent				
Batch 1	6.3	5.2	4.5	
Batch 2	6.7	7.2	4.2	
Batch 3	3.1	4.7	4.5	
Average	5.4	5.7	4.4	———

Following are listed the results of tests performed on the higher slump concrete batches:

	Reference Concrete (Average Results)	Daracem 100 Concrete AASHTO M 194-84I Type F (Individual Results)	Type G (Individual Results)
Slump, inches	3 1/4	5 3/4	9 1/2
Air Content, percent	5.2	5.8	8.6
Unit Weight, lbs/ft^3	145.11	144.87	140.74
Concrete Temp., °F	71	71	71
Water Content, lbs/yd^3	259	248	246
Percent of Reference		96	95

	Reference Concrete (Average Results)	Daracem 100 Concrete AASHTO M 194-84I Type F (Individual Results)	Daracem 100 Concrete AASHTO M 194-84I Type G (Individual Results)
Time of Setting, Hrs:Min			
Initial Set	5:08	6:15	9:03
Deviation from Reference		1:07 (later)	3:55 (later)
Final Set	6:42	7:36	10:42
Deviation from Reference		0:54 (later)	4:00 (later)
Compressive Strength, psi			
1 day	2122	3509	2423
Percent of Reference		168	114
3 days	3568	4359	3926
Percent of Reference		122	110
7 days	4153	5058	4492
Percent of Reference		122	108
28 days	5742	6543	6543
Percent of Reference		114	114
Resistance to Freezing & Thawing - 300 cycles			
Durability Factor	97.0	98.6	94.4
Relative Durability Factor	-	101.6	97.3
Weight Loss, percent	5.4	4.7	7.7

The results of tests to determine rate of slump loss are as follows:

Rate of Slump Loss

Time following Completion of Mixing, Hrs:Min	Daracem 100 Concrete AASHTO M 194-84I Type F Slump, inches	Daracem 100 Concrete AASHTO M 194-84I Type G Slump, inches
0:00	5 3/4	9 1/2
0:15	3 1/2	8 3/4
0:30	3	8 1/2
0:45	2 1/2	8 1/4
1:00	2	8
1:15	1 3/4	7 3/4
1:30	1 1/4	7 1/2
1:45		6 3/4
2:00		6 1/2
2:15		6
2:30		5 1/2
2:45		4
3:00		3 1/4
3:15		3

SUMMARY & CONCLUSIONS

A. SPECIFICATION COMPLIANCE BATCHES

1) Slumps generally were within the ranges required for VAOT Class B concrete and AASHTO M 194-84I. Slumps not within those ranges did not appear to adversely affect other test results.

2) Individual air contents of all concretes varied considerably, however, average results of the test concrete batches were within 0.5 percent of the reference concrete as required.

3) The maximum water content, expressed as a percent of the reference batches, was in compliance with requirements for the Daracem 100 when used as both a Type F and Type G admixture. Increasing the addition rate of the admixture to achieve the desired retardation reduced the water content from 88 percent of reference as a Type F admixture to 82 percent of reference as a Type G admixture.

4) The Daracem 100 complied with initial and final time of setting requirements as both a Type F and Type G admixture. The film or crust noted during initial time of setting tests on specimens containing Daracem 100 indicates possible problems may be encountered when delayed finishing or finishing of large areas is necessary.

5) Compressive strengths, expressed as a percent of reference, were in compliance with requirements at all ages of test for the material used as a Type F and a Type G admixture. Substantial strength increases were noted at all ages of test when the addition rate was increased to provide the properties of a Type G admixture.

6) Concrete containing the Daracem 100 as both a Type F and Type G admixture performed slightly better in sonic testing for resistance to freezing and thawing than the reference concrete. The results after 300 cycles of freezing and thawing were in compliance with requirements for both addition rates. The percent of weight loss of 5.7 percent for the Type F mixes and 4.4 percent for the Type G mixes were very close to the 5.4 percent weight loss for the reference mixes after 300 cycles of freezing and thawing.

B. HIGHER SLUMP BATCHES

1) The 5 3/4 inch slump with the Type F addition rate provided good workability with no segregation. However, segregation was noted at the 9 1/2 inch slump when the Type G addition rate was used.

2) Although the quantity of air entraining admixture was reduced in the higher slump concrete batches, the air contents were equal to or higher than the specification compliance batches.

3) Increasing the slump from 2 1/4 inches to 5 3/4 inches when the material was used as a Type F admixture resulted in an approximate 20 minute later initial and final time of setting. When the material was used as a Type G admixture and the slump increased from 2 3/4 inches to 9 1/2 inches, the additional delay in initial and final time of setting was approximately 2 hours.

4) Compressive strengths of the higher slump batches were greater at all ages of test when compared with the strengths of the reference batches. With the exception of the 1 day strength at the Type F addition rate, the increases in strength at the higher slumps were not as great as the increases experienced with the specification compliance batches.

5) When tested for resistance to freezing and thawing, the higher slump concrete at the Type F addition rate with a 5 3/4 inch slump compared closely with the specification compliance batches. At the Type G addition rate with the 9 1/2 inch slump the relative durability factor was slightly lower, at 97.3 when compared with the specification compliance batches at 100.4. Also, the weight loss was greater at 7.7 percent for the higher slump when compared with 4.4 percent for the specification compliance batches.

6) Rate of slump loss tests performed with the Daracem 100 concrete indicate the reduction in slump was 1 inch for each 23 minutes of elapsed time for the Type F addition rate and 1 inch for each 31 minutes of elapsed time for the Type G addition rate. Alternately, the rate of slump loss at the Type F addition rate was 2.6 inches per hour while at the Type G addition rate it was 1.9 inches per hour.

RECOMMENDATIONS

1) Daracem 100, when tested for 1,3, 7 and 28 day compressive strengths, time of setting, water content and resistance to freezing and thawing, complied with the requirements of AASHTO M 194-84I as both a Type F and Type G admixture. It is recommended for trial use in either prestressed concrete members or other precast applications where it's use can be closely monitored. Care should be exercised to avoid using this material in applications where hand finishing of large surfaces of concrete would be required.

2) When Daracem 100 is used as either a Type F or Type G admixture, it is recommended that a maximum slump of 6 inches be established to avoid possible segregation of the concrete.

3) Use of this material should be under the direction of the Materials and Research Division and it's use employed only with the approval of the Structural Concrete Engineer.

TA 565 Rev. 4/79

Prepared By: W. Meyer WJM
Date: 11/26/84
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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 84-C-18

Subject Laboratory Evaluation of Daracem-100, High Range Water Reducing Admixture and High Range Water Reducing and Retarding Admixture

Investigation Requested By W. R. Grace & Co., Cambridge,MA Date July 16, 1984

Date Information Required As soon as possible

Purpose of Investigation To conduct a laboratory evaluation of Daracem-100 to determine compliance with AASHTO M-194, Type F and AASHTO M-194, Type G, and to examine flowable concrete mixtures using this material. Daracem-100 is used as either a Type F or Type G admixture, depending upon addition rate.

Proposed Tests or Evaluation Procedure The results obtained from three batches of reference concrete will be compared with results obtained from six batches of concrete containing Daracem-100 (three batches as a Type F admixture and three batches as a Type G admixture). Tests will include but not be limited to:

(a) Slump (AASHTO T-119)

(b) Air Content (AASHTO T-152)

(c) Unit Weight (AASHTO T-121)

(d) Time of Set (AASHTO T-197)

(e) Compressive Strength 3,7,28 days (AASHTO T-22)

(f) Resistance to Freezing and Thawing (AASHTO T-161)

(g) Water Content

Additional batches will be used to examine flowable concretes for the above properties as well as to determine rate of slump loss of flowable mixtures. Class B concrete will be used throughout this evaluation.

Proposal Discussed With C. Benda, D. Brown, N. Danforth, R. Frascoia

Projected Manpower Requirements 30 man days

Investigation To Be Conducted By Structural Concrete Subdivision

Proposed Starting Date December 3, 1984 Estimated Completion Date March 1, 1985

Approval/Disapproval by Materials & Research Engineer R. F. Richardson 12-12-84

Comments by Materials & Research Engineer

Materials & Research Division
Agency of Transportation
Date Typed: December 10, 1984