STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

STRENGTH OF CONCRETE
CLASS AA MODIFIED (4 1/2" to 5" SLUMP)

REPORT 79-2
FEBRUARY 1979

REPORTING ON WORK PLAN NO. 78-C-41

R.E.W. Crisman, Secretary of Transportation
S.J. Gage, Director of Engineering and Construction
R.F. Nicholson, P.E., Materials & Research Engineer

Prepared By

E.R. Waibel, P.E., Structural Concrete Engineer
Structural Concrete Subdivision

Reviewed by:

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

Date: 3/27/79

State of Vermont
Agency of Transportation
Materials & Research Division
March 27, 1979

TABLE OF CONTENTS

INTRODUCTION

Difficulty has been experienced in the past in placing (1" - 2 1/2" slump) Concrete Class AA in steel grid flooring. This investigation was requested by the Construction Division to investigate the use of Concrete Class AA Modified with a 4 1/2" to 5" slump for use in filling steel grid flooring.

Three trial mixes using 705, 750 and 800 lb/cy cement content were used in this investigation. The object was to determine the cement content required to yield a compressive strength of 3750 psi in seven days using a Type II portland cement.

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

MATERIALS

Following are listed the materials used in this investigation:

Coarse Aggregate(Item 704.02):

3/8" Stone - Calkins Redimix, Coventry, Vermont

Fine Aggregate (Item 704.01):

Calkins Redimix, Coventry, Vermont

Cement (Item 701.01):

Type II - Northeast Cement Co., Inc., St. Constant, Quebec

Admixtures:

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

Retarding:
Daratard 17-- Construction Products Division W.R. Grace & Co., Cambridge, Mass.

PROCEDURES

The Class AA Modified(705, 750 and 800 Lbs/cy cement) concrete was designed following the procedures outlined in ACI Standard 211.1-70, "Recommended Practice for Selecting Proportions for Normal Weight Concrete".

Three batches of concrete were prepared, one batch for each cement content investigated. All concrete was mixed in a Lancaster mixer.

After mixing, each batch of concrete was tested for air content, slump, unit weight, yield, and 4, 7, 10, 14, and 28 day compressive strength.

CONCLUSIONS

The purpose of the trial mixes was to determine a mix design for Concrete Class AA Modified with type II cement which would produce concrete that would yield a compressive strength of 3750 psi in seven days.

The compressive strength of 3750 psi was selected as the desired strength. This strength was selected, in part, as a result of a discussion with W. M. Smith, Structures Engineer, on September 18, 1978.

The test results obtained from our trial mixes indicated only trial mix #3 produced the required 7 day compressive strength. A cement content of 800 Lbs/cy was used for trial mix #3.

A series of test values are needed to predict, with any degree of accuracy, the strength ability of a particular design. However, the results of a single trial mix do indicate whether or not a mix design is realistic. The test results of these trial mixes appear to be realistic.

RECOMMENDATIONS

Difficulty has been experienced in placing(1 - 2 1/2" slump) concrete Class AA in steel grid flooring. Based on trial mixes, this investigation indicates a Concrete Class AA Modified with 800 Lb/cy cement content and 4 1/2" to 5" slump will yield concrete with a 3750 psi compressive strength in seven days. It is recommended this mix be used for filling steel grid flooring requiring a seven day compressive strength of 3750 psi.

Compressive strengths should be monitored with 6" x 12" cylinders.

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

HD 565 3/78

Prepared By: E. Maibel
Date: 11/28/78
Sheet 1 of 1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 78-C-41

Subject Strength of Concrete, Class AA, with a 4½" to 5" slump

Investigation Requested By Nelson Duba, Chief Resident Engineer of Bridges Date October 30, 1978

Date Information Required March, 1979

Purpose of Investigation Investigate the feasibility of using 4½" to 5" slump for filling Steel Grid Flooring. This investigation is being done for Richford 105A-B3. Tests will be performed using 705, 750 and 800 lbs/cy cement content. Daratard 17 (3½ oz/cwt) and a sufficient quantity of Darex (entrained air 7% ± 1) will also be used.

Proposed Tests or Evaluation Procedure

1. Aggregates will be tested for compliance with Item 704.01 and Item 704.02.
2. Compressive strengths - 4 days, 7 days, 10 days, 28 days.

Proposal Discussed With N. Duba, R. Frascoia, H. Haggerty

Projected Manpower Requirements Preparation & Testing - 7 man days, Report - 3 man days

Investigation To Be Conducted By Structural Concrete Subdivision

Proposed Starting Date November, 1978 Estimated Completion Date March, 1979

Approval/Disapproval by Materials Engineer R. A. Nicholson 11/28/78

Comments by Materials Engineer

AGENCY OF TRANSPORTATION

OFFICE MEMORANDUM

TO: John R. Phalen, Construction Engineer

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

DATE: September 21, 1978

SUBJECT: Richford 10SA-BR 3

As mentioned in Nelson Duba's August 1 memo on the Richford pre-construction conference, the shortest haul is one hour from the project. Past experience also indicates that placement of the concrete with proper vibration into a grid floor will be a time consuming operation. The following ways of reducing the transit time prior to placement were discussed.

1. The use of a concrete mobile.

2. Charging the truck mixers with sand, stone and water and adding the cement at the job site.

3. Using a Type II cement with retarder. Dosage will be determined depending on the conditions at the time of placement. Retempering should not be allowed.

Project plans call for the superstructure concrete to be Class AA modified, to yield a compressive strength of 4000 psi in seven days using a Type III high early strength portland cement.

Our test results indicate that the seven day strength of a properly cured AA concrete using a Type II cement will be in the range of 3750 psi.

On September 18, I spoke with W. M. Smith concerning the seven day strength required on the plans. He said it would be acceptable to reduce the required seven day strength to 3500 psi. Therefore, all three options would be available to the contractor.

I recommend you request a change order allowing the use of Type II cement with a retarder and also reducing the allowable seven day strength to 3500 psi on any option.

RFN/ERW/ed

cc: RFN/Lab File
W. M. Smith
N. Duba
Central Files
Haggerty/Structural Concrete File

HD 182F 2M 3/78

2
Office
Unibel

VERMONT AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION

Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report November 24, 19 78

Laboratory No. G7800829 Tested By P. Rock

Name Fine Aggregate for Concrete Item 501

Identification Marks Preliminary Sample

Submitted by P. Rock Title PFP Address

Sampled 11/14, 19 78 Received 11/14, 19 78

Sample from Stockpile @ Calkins Coventry, VT

Quantity Represented

Source of Material Calkins Coventry, VT

Location used or to be used Possible Future Use

Examined for Item 704.01

TEST RESULTS

Total Sample Sieve Size	% Passing
4 1/2"	
4"	
3 1/2"	
3"	
2 1/2"	
2"	
1 3/4"	
1 1/2"	
1"	
3/4"	
5/8"	
1/2"	
3/8"	100
No. 4	99
No. 8	88
No. 10	
No. 16	64
No. 30	38
No. 50	15
No. 100	5
No. 200	

Sand Portion

Fineness Modulus % Coarser Than

No. 100	95
No. 50	85
No. 30	62
No. 16	36
No. 8	12
No. 4	1

Fineness Modulus = 2.91

Color -1

Comments:

Percent of Wear

AASHTO T3
AASHTO T4
AASHTO T96

Fractured Faces, %

Thin & Elongated Pieces, %

Soundness, % Loss

This material meets the gradation and color requirement for Item 704.01.

ACCEPTED

S. J. Gage, Chief Engineer

By: R. F. Nicholson 1807

R. F. Nicholson, Materials Engineer

lmg

HD 182F 2M 3/78

2
Office

VERMONT AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION

Montpelier, Vermont 05602

REPORT ON SAMPLE OF AGGREGATE

Report November 24, 19 78

Laboratory No. G7800823 Tested By P. Rock

Name Coarse Aggregate for Concrete Item 501

Identification Marks Preliminary Sample 3/8" Stone

Submitted by P. Rock Title PFP Address

Sampled 11/14, 1978 Received 11/14, 1978

Sample from Stockpile @ Calkins Coventry, VT

Quantity Represented

Source of Material Calkins Coventry, VT

Location used or to be used Possible Future Use

Examined for Item 704.02

TEST RESULTS

Total Sample Sieve Size	% Passing
4 1/2"	
4"	
3 1/2"	
3"	
2 1/2"	
2"	
1 3/4"	
1 1/2"	
1"	
3/4"	
5/8"	
1/2"	100
3/8"	99
No. 4	25
No. 8	5
No. 10	
No. 16	2
No. 30	
No. 50	
No. 100	
No. 200	

Sand Portion

Fineness Modulus % Coarser Than	
No. 100	
No. 50	
No. 30	
No. 16	
No. 8	
No. 4	

Fineness Modulus =

Percent of Wear

AASHTO T3

AASHTO T4

AASHTO T96

Fractured Faces, % 93

Thin & Elongated Pieces, % 5

Soundness, % Loss

Comments:

This material meets the gradation, thin and elongated piece, and fractured face requirements for Item 704.02.

ACCEPTED

E. J. Gage, Chief Engineer

By: [illegible] 1Qa7

R. F. Nicholson, Materials Engineer

lmg

Prep. by: W. L. Meyer
Date: 11/22/78

STATE OF VERMONT - AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

MIX DESIGN - STRUCTURAL CONCRETE ITEM # 501 CONCRETE CLASS AA

Ready Mix Supplier: Calkins - Coventry, Vt.

Aggregate Supplier:	Specific Gravity	Dry Rodded Unit Weight	Absorption
___" Stone			
3/8" Stone Calkins - Coventry, Vt.	2.65	104.89	1.8
Sand Calkins - Coventry, Vt.	2.62	F.M. 2.91	2.1

Cement 705 Lbs/CY
Water W/C.40 Gals/CY
Air 7 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
3/8"	0.48	0.47	0.46	0.45	0.44	0.43
3/4"	0.64	0.63	0.62	0.61	0.60	0.59
1-1/2"	0.73	0.72	0.71	0.70	0.69	0.68

104.89 (Dry Rodded Unit Weight) X .45 (Unit Volume) = 47.2005 X 27 = 1274 Lbs/CY Coarse Aggregate

1. Volume of Water (Gals/CY) 33.8 / 7.48 = 4.519 CuFt
2. Solid Volume of Cement (Lbs/CY 705 / 196.56 = 3.587 CuFt
3. Volume of Entrained Air .07 X 27 = 1.890 CuFt
4. Solid Volume of Coarse Aggregate (Lbs/CY) 1274 / (SpGr) 2.65 X 62.4 = 7.704 CuFt
5. Total Solid Volume of Ingredients Except Sand 17.700 CuFt
6. Solid Volume of Sand Required 27.00 - 17.700 (Line 5) = 9.300 CuFt
7. Required Weight of Sand:
   (Solid Volume) 9.300 X (SpGr) 262 X 62.4 = 1520 Lbs/CY
8. Ratio of Sand to Total Agg. Line 6 - (Line 6 + Line 4) = 54.7 % by Vol.

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

	Trial # 1	Trial #	Trial #
___" Stone			
3/8" Stone	1274		
Sand	1520		
Cement	705		
Water	33.8		

(See Reverse Side for Results)

Prep. by: W. L. Meyer
Date: 11/22/78

STATE OF VERMONT - AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

MIX DESIGN - STRUCTURAL CONCRETE ITEM # 501 CONCRETE CLASS AA

Ready Mix Supplier: Calkins - Coventry, Vt.

Aggregate Supplier:	Specific Gravity	Dry Rodded Unit Weight	Absorption
___" Stone			
3/8" Stone Calkins - Coventry, Vt.	2.65	104.89	1.8
Sand Calkins - Coventry, Vt.	2.62	F.M. 2.91	2.1

Cement 750 Lbs/CY
Water W/C .40 Gals/CY
Air 7 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
3/8"	0.48	0.47	0.46	0.45	0.44	0.43
3/4"	0.64	0.63	0.62	0.61	0.60	0.59
1-1/2"	0.73	0.72	0.71	0.70	0.69	0.68

104.89 (Dry Rodded Unit Weight) X .45 (Unit Volume) = 47.2005 X 27 = 1274 Lbs/CY Coarse Aggregate

1. Volume of Water (Gals/CY) 35.9 / 7.48 = 4.799 CuFt
2. Solid Volume of Cement (Lbs/CY 750 / 196.56 = 3.816 CuFt
3. Volume of Entrained Air .07 X 27 = 1.890 CuFt
4. Solid Volume of Coarse Aggregate (Lbs/CY) 1274 / (SpGr) 265 X 62.4 = 7.704 CuFt
5. Total Solid Volume of Ingredients Except Sand 18.209 CuFt
6. Solid Volume of Sand Required 27.00 - 18.209 (Line 5) = 8.791 CuFt
7. Required Weight of Sand: (Solid Volume) 8.791 X (SpGr) 262 X 62.4 = 1437 Lbs/CY
8. Ratio of Sand to Total Agg. Line 6 - (Line 6 + Line 4) = 53.3 % by Vol.

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

	Trial # 2	Trial #	Trial #
___" Stone			
3/8" Stone	1274		
Sand	1437		
Cement	750		
Water	35.9		

(See Reverse Side for Results)

Prep. by: E. Waibel
Date: 11/22/78

STATE OF VERMONT - AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

MIX DESIGN - STRUCTURAL CONCRETE ITEM # 501 CONCRETE CLASS AA

Ready Mix Supplier: Calkins - Coventry, Vt.

Aggregate Supplier:	Specific Gravity	Dry Rodded Unit Weight	Absorption
___" Stone			
3/8" Stone	2.65	104.89	1.8
Sand	2.62	F.M. 2.91	2.1

Cement 800 Lbs/CY
Water W/C.40 Gals/CY
Air 7 Percent

$\frac{(800)(.40)}{8.345} = 38.34$

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
3/8"	0.48	0.47	0.46	0.45	0.44	0.43
3/4"	0.64	0.63	0.62	0.61	0.60	0.59
1-1/2"	0.73	0.72	0.71	0.70	0.69	0.68

104.89 (Dry Rodded Unit Weight) X .45 (Unit Volume) = 47.2005 X 27 = 1274 Lbs/CY Coarse Aggregate

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1. Volume of Water $\frac{\text{(Gals/CY) } 38.34}{7.48}$ = 5.127 CuFt

2. Solid Volume of Cement $\frac{\text{(Lbs/CY } 800}{196.56}$ = 4.070 CuFt

3. Volume of Entrained Air .07 X 27 = 1.890 CuFt

4. Solid Volume of Coarse Aggregate $\frac{\text{(Lbs/CY) } 1274}{\text{(SpGr) } 2.65 \text{ X } 62.4}$ = 7.704 CuFt

5. Total Solid Volume of Ingredients Except Sand 18.791 CuFt
6. Solid Volume of Sand Required 27.00 - 18.791 (Line 5) = 8.209 CuFt
7. Required Weight of Sand:
   (Solid Volume) 8.209 X (SpGr) 2.62 X 62.4 = 1342 Lbs/CY
8. Ratio of Sand to Total Agg. Line 6 - (Line 6 + Line 4) = 51.6 % by Vol.

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

	Trial #3	Trial #	Trial #
___" Stone			
3/8" Stone	1274		
Sand	1342		
Cement	800		
Water	38.3		

(See Reverse Side for Results)

STATE OF VERMONT - AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

Structural Concrete - Mix Proportions and Results

Mix Number		705(1)	705(2)		
Mix Design:					
Class of Concrete	Dry	AA	AA		1/18th Dry
Cement - lbs.	705	705	705		39.17
1-1/2" Stone (SSD) - lbs.					
3/ 8" Stone (SSD) - lbs.	1274	1297	1297		70.78
Sand (SSD) - lbs.	1520	1552	1552		84.44
Net Water - lbs.		311	303		
Admixture - oz./cy Darex AEA		4ml	4ml		
Admixture - oz./cwt Daratard 17	3 1/2	41ml	41ml		
Total Batch Weight - lbs.		3865	3857		
Concrete Tests					
Water/Cement Ratio					
Slump - Inches	3 1/2	5 1/4	5 1/2		
Air Content - % (Chace)					
Air Content - % (Pressure)	6.4	6.9	7.0		
Temperature - Deg. F		77	74		
Density - lbs./cu. ft.		140.27	140.67		
Mix Yield - cu. ft.		27.55	27.42		
Calc. Cement Cont. - lbs./c.y.					
Compressive Strength - PSI					
4 Days 12/5/78		3263	3283		
		3223	3104		
Average		3243	3194		
7 Days 12/8/78		3442	3621		
		3501	3581		
Average		3472	3601		
10 Days 12/11/78		3979	4039		
		4138	3820		
Average		4059	3930		
14 Days 12/15/78		4536			
		4635			
		3820			
Average		4330			
28 Days 12/29/78		4735	5053	4474	
		4934	4715 ←	4881	
		4974		4863	
Average		4881	4884	4739	

NOTES:

STATE OF VERMONT - AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

Structural Concrete - Mix Proportions and Results

Mix Number		750(1)	750(2)		
Mix Design:					
Class of Concrete	Dry				1/18th Dry
Cement - lbs.	750	750	750		41.67
1-1/2" Stone (SSD) - lbs.					
3/8" Stone (SSD) - lbs.	1274	1297	1297		70.78
Sand (SSD) - lbs.	1437	1467	1467		79.83
Net Water - lbs.		301	308		
Admixture - oz./cy Darex AEA		5ml	5ml		
Admixture - oz. /cwt Daratard 17	3 1/2	43ml	43ml		
Total Batch Weight - lbs.		3815	3822		
Concrete Tests					
Water/Cement Ratio					
Slump - Inches		4 3/4	5 1/4		
Air Content - % (Chace)					
Air Content - % (Pressure)		6.9	7.0		
Temperature - Deg. F		74	74		
Density - lbs./cu. ft.		140.59	140.07		
Mix Yield - cu. ft.		27.14	27.29		
Calc. Cement Cont. - lbs./c.y.					
Compressive Strength - PSI					
4 Days 12/5/78		3720	3581		
		3601	3044		
Average		3661	3313		
7 Days 12/8/78		4019	3899		
		3661	3820		
Average		3840	3860		
10 Days 12/11/78		4357	4297		
		4039	4138		
Average		4198	4218		
28 Days 12/29/78		5312	5192		
		5491	5153		
Average		5402	5173		
28 Days		5128	4951		
		5040	4810		
		5305	5111		
Average		5158	4957		

NOTES:

STATE OF VERMONT - AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - STRUCTURAL CONCRETE SUBDIVISION

Structural Concrete - Mix Proportions and Results

Mix Number		800(1)	800(2)		1/18th Dry
Mix Design:					
Class of Concrete	Dry				
Cement - lbs.	800	800	800		44.44
1-1/2" Stone (SSD) - lbs.					
3/8" Stone (SSD) - lbs.	1274	1297	1297		70.78
Sand (SSD) - lbs.	1342	1370	1370		74.56
Net Water - lbs.		310	303		
Admixture - oz./cy Darex AEA		6ml	6ml		
Admixture - oz./cwt Daratard 17	3 1/2	46ml	46ml		
Total Batch Weight - lbs.		3777	3770		
Concrete Tests					
Water/Cement Ratic					
Slump - Inches		5 1/2	5 1/2		
Air Content - % (Chace)					
Air Content - % (Pressure)		~~6.1~~	6.9		
Temperature - Deg. F		73	73		
Density - lbs./cu. ft.		142.15	141.03		
Mix Yield - cu. ft.		~~26.57~~	~~26.73~~		
Calc. Cement Cont. - lbs./c.y.					
Compressive Strength - PSI					
4 Days 12/5/78		3601	3919		
		3581	3501		
Average		3591	3710		
7 Days 12/8/78		3939	4118		
		3979	3840		
Average		3959	3979		
10 Days 12/11/78		4397	4536		
		4496	4397		
Average		4447	4467		
28 Days 2.29/78		5292	5192		
		5272	5531		
Average		5282	5362		
28 Days		5500	5155		
		5270	5588		
		5287	5641		
Average		5352	5461		

NOTES: