Special Cements for Fast Track Concrete

Final Report for MLR-87-4

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Highway Division
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SPECIAL CEMENTS FOR FAST TRACK CONCRETE

Final Report

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ABSTRACT

Two specialty cements are currently being marketed as a way to achieve pcc pavement opening strengths at less than 12 hours after placement. The cements are Pyrament from Pyrament/Lone Star Industries of Houston, Texas and Ideal Regulated-Set (RS) Portland Cement from Ideal Cement Company of Saratoga, Arkansas. The objective of the study was to evaluate the strength gain and durability of concrete produced with Pyrament and Ideal RS cement as Fast Track concrete.

Mixes with 610 pounds of cement per cubic yard were made and tested. Both Pyrament and Ideal RS are capable of producing pavement opening times less than 12 hours. Recent changes to Ideal RS cement have produced concrete flexural strengths of 550 psi at 4 hours in Iowa tests. Freeze/thaw durability of the concrete was not adversely affected by using either cement.

INTRODUCTION

Experience with Fast Track concrete in Buena Vista County on highway 71 and in additional projects constructed in 1987 has shown that it is a viable construction alternative for some locations. Sufficient strength is obtained with Fast Track to normally permit construction traffic at 16 to 24 hours after placement. Two cements are currently being marketed as a way to achieve early opening strengths. The cements are Pyrament from Pyrament/Lone Star Industries of Houston, Texas and Ideal Regulated-Set Portland Cement from Ideal Cement Company of Saratoga, Arkansas. For some critical locations, a shorter opening time would be beneficial.

OBJECTIVE

The objective of Phase 1 of the study was to evaluate the strength gain and durability of concrete produced with Pyrament and Ideal Regulated-Set (RS) cement as a Fast Track concrete. If Phase 1 results are favorable, Phase 2 will evaluate the use of Pyrament and RS cement in a paving project.

MATERIALS

The following materials were used in this study (Aggregate gradations are in the Appendix):

Cements - Pyrament, Pyrament/Lone Star Industries, Inc.
Regulated-Set, Ideal Cement Company
Fly Ash - Type C, Ottumwa (ACF7-74)
Coarse Aggregate - Martin Marietta (Ft. Dodge) (AAC6-647)
Fine Aggregate - Cordova, Illinois (AAS6-235)

Air Entraining Agent - Ad Aire Single Strength, Carter-Warters Corp.
Retarding Admixture - Citric Acid
Water Reducing Admixture - WRDA-82, W. R. Grace and Co.
WRDA-19, W. R. Grace and Co.

Table 1 contains the test results on the cements along with typical Type III portland cement results meeting Fast Track specifications.

TABLE 1
Cement Properties

TEST	PYRAMENT	IDEAL R.S.	TYPICAL TYPE III
Normal Consistency	24.6	27.0	25.0
Blaine Fineness	608	487	575
Air Content	10.4	12.7	9.0
Autoclave	0.00	0.01	0.05
12-hour cube strength	970	2140	1300+
1-day cube strength	1250	4180	3000
3-day cube strength	2700	4780	4800
Specific Gravity	2.87	2.99	3.17
Mg 0	2.82	0.77	1.1
S03	2.51	9.18	3.50
Loss on Ignition	3.27	1.97	0.90
Insoluble Residue	6.92	1.42	0.30
Fe203	3.20	1.71	2.00
Al203	10.86	10.22	4.30
Ca0	48.78	58.90	63.50
C3PA	23.37	24.19	11.00
Na20	0.70	0.16	
K20	1.76	1.32	
Na20 Equivalency	1.86	1.03	0.30

PROCEDURE

Normal mix procedures (ASTM C192) were followed for mixing the Pyrament. The Ideal RS specified the following mix procedure:

1. Add coarse aggregates and 3/4 of water.
2. Add citric acid retarder.
3. Add Ideal RS

4. Add air entraining and remaining water.
5. Add fine aggregate.
6. Mix 2-3 minutes

Seven mixes were tested. Tables 2, 3 and 4 contain the results. Durability was determined using a modified ASTM C666 procedure and time of set was determined using ASTM C266.

DISCUSSION OF TESTING

It was quickly discovered that Pyrament was very sensitive to water changes. A small increase in the amount of mix water (w/c increase of 0.012) caused a large change in the slump of the mix (slump from 1.75" to 5+"). The initial set was 1.9 hours. The technical representative for Pyrament indicated that no retarder would work on this cement.

The Ideal RS was very insensitive to water changes once mixing was in process. A large increase in the amount of mix water (w/c increase of 0.25) caused no change in the slump of the mix. Without citric acid, the mix set too quickly to obtain a time of set sample. Using 0.20% of citric acid, initial set was 0.8 hours.

DISCUSSION OF RESULTS

Both mixes generated heat equal to or higher than Type III cement mixes normally do. It is likely that the temperature of the specimens in the laboratory is well below what would be achieved by the same mix in a pavement on a summer day. Flexural strengths on both

TABLE 2 - Mix Properties

Mix No.	Type	Cement #/YD3	Fly Ash #/YD3	W/C	Retarder oz/100A of Cement	Reducer	Air Content (%)	Slump (IN.)	Cure	Int. SE (Hours)
1	Pyrament	610	0	0.297			3.8	0.75	STD.	
2	Pyrament	610	0	0.299			6.2	1.75	STD.	
3	Pyrament	610	0	0.285			5.6	1.25	INSUL.	1.9
4	Pyrament	549	61	0.271			5.5	1.0	INSUL.	
5	Ideal R.S.	610	0	0.376	0.20	*WRDA 82	9.5	5.25	INSUL.	0.8
6	Ideal R.S.	610	0	0.439		WRDA 19	6.4	2.25	INSUL.	>0.5
7	Ideal R.S.	549	61	0.377		WRDA 82	6.8	0.75	STD.	

*Switched to WRDA 19 Super Water Reducer W/C=0.286, Air Content 4.8%, Slump 3.0 inches

TABLE 3 - STRENGTH OF MIXES

Mix. No.	Type	FLEXUAL STRENGTH (P.S.I.) 4-HR	8-HR	12-HR	24-HR	COMPRESSIVE STRENGTH (P.S.I.) 4-HR	8-HR	12-HR	24-HR	28-Day	Durability
1	PYRAMENT										96
2	PYRAMENT		410	510	570		1720	1940	2520	9350	100
3	PYRAMENT	315	325	525		1350	1550	2360	2470		
4	PYRAMENT W/F. A.	270	370	345		1400	1790	1870	2400	8970	
5	IDEAL R.S.	325	*545	500		1600	2500	2820	3570	6190	97
6	IDEAL R.S.	290	370	410		1770	2230	2680	3140		
7	IDEAL R.S. W/F. A.	320	370	430		2090	2200	2760	3690	6040	

TABLE 4 - TEMPERATUES OF SAMPLE (DEG. F.)

Mix No.	Type	MIX	1-HR	2-HR	3-HR	4-HR	5-HR	6-HR	7-HR	8-HR	12-HR	24-HR
1	PYRAMENT											
2	PYRAMENT	80	86	87	87	88	87	86	82	81	80	
3	PYRAMENT	76				85				85	82	72
4	PYRAMENT W/F. A.	80	78	79	88	88				83	79	74
5	IDEAL R.S.	72	79	87	97	97				91	79	73
6	IDEAL R.S.	74	92	93	91	90	89	88	87	87	87	76
7	IDEAL R.S. W/F. A.	75	94	94	91	89				82	82	74

Ideal RS and Pyrament ranged higher at 4 and 8 hours than what routinely would be achieved with fast track concrete in the field. Figure 1 shows this graphically.

The 610 pounds of cement per cubic yard of concrete would be a typical amount for a standard primary paving mixture. Both cements achieved significant flexural strengths (300 psi plus) at four hours after mixing. Ideal has since started adding a dry form of high range water reducer to the RS cement at the cement mill. Mixes produced at Central Ready Mix at Indianola using the "new" regulated-set cement produced flexural strengths of 550 psi at 4 hours and 700 psi at 8 hours. The highest cement content was 710 pounds of RS cement per cubic yard. This work was done November 24, 1987 without a retarding admixture.

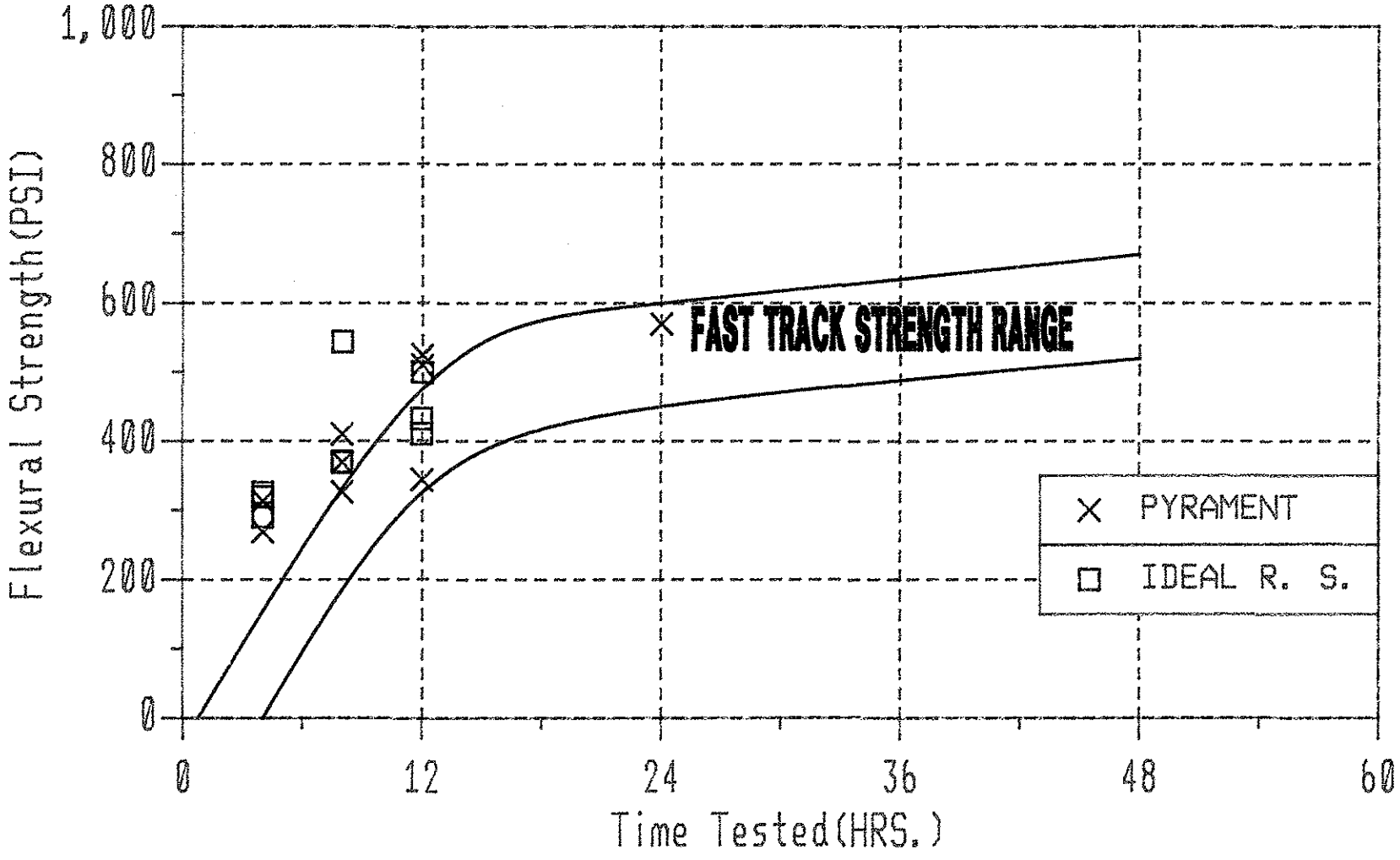
The use of a 10 percent replacement of cement with fly ash did not significantly reduce the strength gain of the RS cement. At 12 hours, the flexural strength of Pyrament with fly ash was 180 psi lower than the comparable mix without fly ash.

The durability of the mixes as measured by ASTM C666, Method B modified freeze and thaw, was above 90 in all cases. Pyrament with and without air entraining performed similarly.

COST

Both Pyrament and Ideal R.S. would be about $150.00 per ton at the mill.

FIGURE 1. FLEXURAL STRENGTH COMPARISON



CONCLUSIONS

The following conclusions are:

1. Slump may not be a reliable construction test for either a Pyrament mix or an Ideal RS mix.

2. The set time of Ideal RS cement is generally too short for field use without using a retarding admixture.

3. The 1.86% alkali content of Pyrament is well above the 0.9% limit specified for Type I and Type III portland cements in Iowa.

4. The "new" Ideal Regulated-Set cement is capable of producing concrete that could be opened to traffic in 4 hours. Pyrament has early strength-gain properties, but flexural strengths in the lab would suggest an 8 to 12 hour opening at a 610 pound cement factor.

RECOMMENDATIONS

1. Both Pyrament and Ideal Regulated-Set Cement have sufficient potential to warrant a field trial.

2. Both cements are significantly different than portland cement. Technical representatives should be on site during all mixing and placement to advise the contractor during a field trial.

3. A maximum water/cement ratio should be used instead of slump to control mix water and consistency. The water/cement ratio would need to be established using trial mixes.