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FINAL REPORT

84-3

FREEZE-AND-THAW DURABILITY OF FLY ASH CONCRETE

MISSOURI HIGHWAY AND TRANSPORTATION DEPARTMENT

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16. Abstract

The primary objective of this study was to investigate strength, freeze-and-thaw durability, and air-void system characteristics of concrete utilizing fly ash to replace various amounts of cement in the mix design. All mixes were designed with 6.1 sacks of cement per cubic yard, 45% of aggregate as sand, and 5.5% air. Limestone aggregate from two sources was used with Class C fly ash from four sources. Cement was replaced with fly ash on a pound for pound basis at percentages of 0, 10, 20, and 30. Durability of concrete generally decreased slightly as percentage of fly ash increased. Strength gain was generally slower for concrete with fly ash than for control concrete. Air-void system characteristics were comparable for all concretes. Fly ash is presently allowed as a replacement, on a pound for pound basis, for up to 15% of cement except in concrete requiring high early strengths. Results of this study indicate that replacement of more than 15% cement with fly ash would require more extensive testing of each source of fly ash, cement, and aggregate and cannot be justified. No major revision of present requirements is anticipated at this time.

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FREEZE AND THAW DURABILITY OF FLY ASH CONCRETE

STUDY 84-3

Prepared By

MISSOURI HIGHWAY AND TRANSPORTATION DEPARTMENT

DIVISION OF MATERIALS AND RESEARCH

AUGUST 1987

In Cooperation With

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

The opinions, findings, and conclusions expressed in this publication are not necessarily those of the Federal Highway Administration.

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LIST OF ABBREVIATIONS

Abbreviation	Name
Aggr	Aggregate
Bbls	Bubbles
BF	Bethany Falls Limestone
Cem	Cement
Cu Yd	Cubic Yard
Cy	Cycles
D	Days
F	Factor
Mod	Modulus of Elasticity
Pct	Percent
Plat	Plattin Limestone
Psi	Pounds per square inch
Repl	Replacement
Spac	Spacing
Sk	Sack(s)
Term	Terminal

INTRODUCTION

Utilization of fly ash as a partial replacement of concrete is an allowable alternate for most concrete use on the Missouri Highway System. At the time fly ash was first permitted, the Missouri Highway and Transportation Department did not have prior experience with fly ash concrete. This laboratory study was initiated to measure strength, freeze-and-thaw durability, and air-void system characteristics of concrete with Class C fly ash from four sources.

Since no sources of fly ash were approved at the time this study was initiated, the following four sources were selected because they had been supplying material to commercial concrete producers and were likely to be among the first to seek approval for supplying material to the department. Each source is identified by assigned code, location, and company name as follows:

Code A -- Joliet, Commonwealth Edison producer, American Fly Ash Company distributor

Code B -- Iatan, Kansas City Power and Light Company

Code C -- LaCygne, Kansas City Power and Light Company

Code D -- Nearman, Board of Public Utilities

Plattin limestone, an aggregate with no known history of D-Cracking in concrete was used with Joliet fly ash while Bethany Falls limestone, an aggregate with a known history of D-Cracking was used with all four sources of fly ash. Missouri Portland cement, Carter Waters AdAire Extra Strength air-entraining agent, and Missouri River sand were used in all combinations.

Cement factor of 6.1 sacks per cubic yard, 45 percent of total aggregate as sand, slump of less than 3", and air-entrainment at 5.5±1.5 percent were specifications common to all mixes. Limestone coarse aggregate met the requirements of Gradation D. All coarse aggregate retained on the #4 sieve was vacuum saturated prior to batching.

Cement was replaced by fly ash on a pound for pound basis. Replacement percentages of 0, 10, 20, and 30 were used with each combination of coarse aggregate and fly ash for a total of 17 mix designs. Specific combinations of aggregate and fly ash are shown in Tables 3 through 5 along with concrete characteristics, compressive strengths, flexural strengths, air-void system characteristics, and performance of beams subjected to freeze-and-thaw cycling.

CONCLUSIONS

Conclusions are based on laboratory data obtained in this study. Generalizations beyond these materials and mix designs may not be warranted.

1. Not all sources of fly ash performed equally in resistance to freeze-and-thaw cycling.
2. Mixes with 30% of cement replaced by fly ash were generally the first to show significant difference in performance from control mixes with no fly ash.
3. The same source of fly ash did not perform the same with both sources of coarse aggregate. Joliet fly ash caused a decrease in performance with Bethany Falls limestone but not with Plattin limestone.
4. Increased volume of fly ash above that of the cement which is replaced was roughly compensated by reduced water requirements of concrete containing fly ash. This meant almost constant aggregate batch weights for all mix designs with the same aggregate and fly ash.
6. Nominal increases in air agent were required when percentage of fly ash was increased, but no unusual problems in control of air content were experienced.
7. Air void spacing factor remained about the same or improved slightly when a portion of the cement was replaced by fly ash. All spacing factors met ACI recommendations of less than 0.008 inches.

8. Compressive strength was not strongly influenced by percentage of cement replaced by fly ash. Strengths of some mixes with fly ash were lower than control mixes at early ages, but generally had higher ultimate values.

9. Changes in flexural strength were generally small and had no established pattern when a portion of the cement was replaced by fly ash.

10. Final setting time generally increased as amount of fly ash in the concrete increased. Initial setting time followed the same trend for three sources of fly ash but was reversed for the fourth source.

11. Durability factor and expansion per cycle were apparently equally effective methods for measuring resistance to freeze-and-thaw cycling.

IMPLEMENTATION

Fly ash is presently allowed as a replacement, on a pound for pound basis, for up to 15% of cement except in concrete requiring high early strengths. Results of this study indicate that replacement of more than 15% cement with fly ash would require more extensive testing of each source of fly ash, cement, and aggregate and cannot be justified. No major revision of present requirements is anticipated at this time.

SCOPE

The primary objective of this study was to evaluate the durability of concrete when a portion of the cement was replaced by fly ash. Evaluation included freeze-and-thaw durability, expansion per cycle of freeze-and-thaw, compressive strength, flexural strength, and air-void system characteristics.

A mix design typical of those which were currently being used for concrete pavement in the areas of the state with D-Cracking problems was selected for evaluation purposes.

DISCUSSION

This study was initiated to provide an indication of the durability of concrete when a portion of the cement was replaced by fly ash from each of four readily available sources. Laboratory freeze-and-thaw cycling was selected as the most appropriate method for preliminary evaluation of this durability. Relative dynamic modulus, weight change, and expansion were monitored after each weekly freeze cycle. Except for the long soak period, freeze-and-thaw cycling generally met the requirements of ASTM C666. Compressive strength, flexural strength, and air-void system characteristics were also evaluated.

Two coarse aggregate sources were selected with which to evaluate performance of concrete containing fly ash. Plattin limestone, an aggregate with no known history of D-Cracking in concrete was used with one source of fly ash while Bethany Falls limestone, an aggregate with a known history of D-Cracking was used with all four sources of fly ash. Limestone coarse aggregate met the requirements of Gradation D. All coarse aggregate retained on the #4 sieve was vacuum saturated prior to batching.

Missouri Portland cement, Carter-Waters AdAire Extra Strength air-entraining agent, and Missouri River sand were used in all combinations. Cement factor of 6.1 sacks per cubic yard, 45% of total aggregate as sand, slump of less than 3.0 inches and air-entrainment at 5.5 ± 1.5 percent were specifications common to all mixes.

Cement was replaced by fly ash on a pound for pound basis. Replacement percentages of 0, 10, 20, and 30 were used with each of five combinations of coarse aggregate and fly ash for a total of 17 mix designs.

Three batches of concrete were mixed for each combination of coarse aggregate, fly ash source, and percentage of cement replaced by fly ash. There were 13 mix designs with Bethany Falls Limestone coarse aggregate and four mix designs with Plattin Limestone coarse aggregate.

One beam from each of the three batches for each mix design was subjected to freeze-and-thaw cycling at 35 days, flexural strength at 7 days, and flexural strength at 35 days. One cylinder each from two of the three batches for each mix design was examined for air-void system characteristics by linear traverse methods (ASTM C457). One cylinder each from two of the three batches was evaluated for compressive strength at 3, 5, 7, 28, and 56 days. The two batches from which cylinders were selected for any particular evaluation were randomly selected from the three batches.

Comparable air content and slump for all mix designs was necessary for determining relative performance of various combinations of coarse aggregate and fly ash. Nominal increases in air agent were required when percentage of fly ash increased, but problems controlling air content were no greater than those experienced with control concrete. Air content of individual batches of fresh concrete ranged from 5.2 to 6.4 percent. Slump of individual batches ranged from 1.6 to 2.5 inches.

Water requirement dropped steadily as percentage of fly ash increased. This reduced volume of water roughly compensated for the increase in volume of fly ash over that of the cement which was replaced. Consequently, batch weights of aggregate were essentially constant for all mix designs with a particular aggregate. Control of batches was considered to be very good as indicated by the range in air content and slump noted above and by corrected cement factor (or cement and fly ash factor) ranging only from 6.05 to 6.13 sacks per cubic yard.

Performance of concrete containing fly ash as partial replacement for cement varied with source of fly ash and with percentage replacement from a single source. Higher percentages of fly ash generally performed poorer than lower percentages for those sources exhibiting a difference in performance. See Tables 3 through 7 for a comparison of durability, percent expansion, concrete strength, mortar strength, and setting time for all combinations of fly ash. Other data on design and physical characteristics can also be found in tables.

Fly ash from Joliet was used with both coarse aggregates. Performance with Plattin limestone was about the same for all percentages of fly ash. Performance with Bethany Falls limestone tended to decrease as the percentage of fly ash increased. See Table 4 for durability and expansion results.

All other sources of fly ash were used only in the Bethany Falls limestone coarse aggregate series. Even among those fly ash sources with a common coarse aggregate, magnitude of change in performance was not consistent between percentages or sources. There was generally a decrease in performance with an increase in

percentage of cement replaced by fly ash.

Fly ash from Iatan showed decreasing performance with increasing percentage of fly ash. See Table 4 for durability and expansion results.

Fly ash from LaCygne showed a slight decrease in performance with increasing percentage of fly ash. See Table 4 for durability and expansion results.

Fly ash from Nearman showed small decreases in performance with increasing percentages of fly ash. See Table 4 for durability and expansion results.

Compressive strength of concrete with a portion of the cement replaced by fly ash was generally lower than control concrete at early ages but higher ultimate strength values were often achieved. This was only a general trend, and was not true for all mixes. See Table 3. Some apparent irregularities in compressive strength can be attributed to testing only two of three batches at any given age.

Changes in flexural strength were generally small and had no established pattern when a portion of the cement was replaced by fly ash. See Table 3. Flexural strengths were determined only for ages where there was no consistent pattern for compressive strengths. All three batches for any mix design are represented in the flexural strength table.

Air void spacing factor changed very little with source or percentage of fly ash. There was a slight tendency for more small bubbles (and slightly better spacing factors) as percentage of fly ash increased. All spacing factors of laboratory prepared

cylinders which were evaluated met the ACI recommendations of less than 0.008 inches. Portland Cement Concrete Pavement with the same mix design would probably have borderline air void spacing factors because larger spacing factors are usually found in pavements than in cylinders prepared from the same mix as the pavement.

Final setting time was longer for all mixes with fly ash than for control. Initial setting time was generally longer for mixes with fly ash, but there were instances of decreased initial setting time for one fly ash source. See Table 7 for setting time data from this study.

A separate study on setting times included three sources of Type I cement and four sources of fly ash. Cement replacement was at 0, 10, 20, 30, 40, and 100 percent. Three of the fly ash sources were Class C and one was Class F. Initial and final setting times for each variable are shown in Table 8. This data indicates setting time may vary between combinations of cement source and fly ash source.

Durability factor and expansion per cycle were apparently equally effective methods for measuring resistance to freeze-and-thaw cycling. While these methods measure different parameters, both are measures of internal deterioration of concrete.

Table 1

CONCRETE MIX DESIGN FACTORS

Cement Factor (Sk/cu yd)	6.10
Slump (Inches)	3.0 Max
Air Content (Percent)	5.5±1.5
Fly Ash (Percent of Cement; 1:1 by weight)	0 - 30

Aggregate Proportions by Absolute Volume:

45% Class A Missouri River Sand

55% Coarse Aggregate (Gradation D)
Bethany Falls Ls. was used in 13 designs
Plattin Ls. was used in four designs

All coarse aggregate retained on the #4 sieve was vacuum saturated, while all other aggregate was air dried at the time of batching.

Missouri Standard Specifications of Highway Construction, 1981

Coarse aggregate: Section 1005.1 and Gradation D requirements of Section 1005.1.5

Fine aggregate: Section 1005.2 and Gradation requirements of Section 1005.2.4.1

Table 2

CHARACTERISTICS OF FRESH CONCRETE

Cement Factor (Sk/cu yd)	6.05 - 6.13
Slump (Inches)	1.6 - 2.5
Air Content (Percent)	5.2 - 6.4

Table 3

AVERAGE STRENGTH OF CONTROL CYLINDERS AND BEAMS

Set	Coarse Aggr	Fly Ash Source	Pct Cem Repl	Compressive Strength 3 d	5 d	7 d	28 d	56 d	Flexural Strength 7 d	35 d
BA1	BF	Joliet	10	3890	4300	4720	5900	6580	923	975
BA2	BF	Joliet	20	3600	4130	4660	5420	6650	832	935
BA3	BF	Joliet	30	3340	4160	4500	6010	6320	850	982
BB1	BF	Iatan	10	4000	4280	4690	5920	6040	888	959
BB2	BF	Iatan	20	3680	4480	4840	5680	6580	903	925
BB3	BF	Iatan	30	3640	4400	4700	5880	6510	875	950
BC1	BF	LaCygne	10	4060	4310	4710	5920	5810	918	943
BC2	BF	LaCygne	20	3540	4240	4740	5750	5960	885	906
BC3	BF	LaCygne	30	3480	4260	4670	5720	6240	852	870
BD1	BF	Nearman	10	3860	4480	5020	6120	6170	916	952
BD2	BF	Nearman	20	3910	4600	4830	5970	6560	896	964
BD3	BF	Nearman	30	3880	4260	5220	6100	6790	866	921
BNO	BF	None	0	3780	4340	4540	5460	6140	868	907
PA1	Plat	Joliet	10	3900	4270	4580	5680	5850	940	913
PA2	Plat	Joliet	20	3660	4250	4460	5940	6660	934	921
PA3	Plat	Joliet	30	3420	4070	4420	6070	7230	880	1042
PNO	Plat	None	0	4010	4450	4690	5840	5980	954	1011

Table 4

DURABILITY AND EXPANSION OF FREEZE-AND-THAW BEAMS

Set	Aggr	Fly Ash Source	Pct Cem Repl	Initial Mod 35 d	DF	% Expansion Term	% Expansion Per 100 Cy	Cy at Term
BA1	BF	Joliet	10	6.24	43	0.103	0.167	62
BA2	BF	Joliet	20	6.28	34	0.117	0.239	49
BA3	BF	Joliet	30	6.38	35	0.138	0.273	51
BB1	BF	Iatan	10	6.24	48	0.104	0.151	69
BB2	BF	Iatan	20	6.28	45	0.102	0.158	66
BB3	BF	Iatan	30	6.35	34	0.106	0.216	49
BC1	BF	LaCygne	10	6.20	50	0.108	0.151	71
BC2	BF	LaCygne	20	6.34	50	0.105	0.150	71
BC3	BF	LaCygne	30	6.17	44	0.104	0.163	64
BD1	BF	Nearman	10	6.18	53	0.107	0.145	75
BD2	BF	Nearman	20	6.34	52	0.107	0.145	74
BD3	BF	Nearman	30	6.32	35	0.107	0.213	51
BNO	BF	None	0	5.97	56	0.129	0.162	80
PA1	Plat	Joliet	10	6.53	41	0.124	0.210	59
PA2	Plat	Joliet	20	6.67	41	0.138	0.241	59
PA3	Plat	Joliet	30	6.66	49	0.151	0.216	70
PNO	Plat	None	0	6.54	42	0.116	0.192	60

Table 5

LINEAR TRAVERSE DATA

Beam Set	Coarse Aggr	Fly Ash Source	Pct Cem Repl	Percent Air: Fresh Conc All Bbls	Percent Air: Hardened Conc All Bbls	Percent Air: Hardened Mortar All Bbls	Percent Air: Hardened Mortar Bbls (1)	Percent: Bbls (1)	Percent: Mortar	Spac Fact
BA1	BF	Joliet	10	5.9	4.72	8.58	3.57	41.6	55.0	0.0058
				6.3	3.71	6.42	3.18	49.5	57.8	0.0050
				6.1	4.22	7.50	3.38	45.6	56.4	0.0054
BA2	BF	Joliet	20	6.0	5.33	8.24	3.74	45.3	64.6	0.0049
				6.0	4.39	7.66	3.52	46.0	57.3	0.0050
				6.0	4.86	7.95	3.63	45.7	60.9	0.0050
BA3	BF	Joliet	30	5.5	5.22	9.38	3.43	36.6	55.7	0.0059
				5.9	4.20	7.01	3.21	45.8	55.7	0.0051
				5.7	4.71	8.20	3.32	41.2	55.7	0.0055
BB1	BF	Iatan	10	5.9	5.37	8.09	3.54	43.8	66.4	0.0057
				6.2	4.67	7.78	3.35	43.0	60.0	0.0053
				6.1	5.02	7.94	3.45	43.4	63.2	0.0055
BB2	BF	Iatan	20	5.7	5.91	9.48	3.64	38.4	62.5	0.0061
				5.9	4.25	7.10	3.20	45.0	59.8	0.0053
				5.8	5.08	8.30	3.42	41.7	61.1	0.0057
BB3	BF	Iatan	30	5.8	4.74	7.82	3.75	48.0	60.6	0.0049
				6.1	5.45	8.72	3.88	44.5	62.5	0.0054
				5.9	5.10	8.27	3.82	46.3	61.6	0.0052
BC1	BF	LaCygne	10	5.2	4.29	7.27	2.78	38.2	59.0	0.0069
				5.8	4.93	7.68	3.18	41.4	64.2	0.0058
				5.5	4.61	7.48	2.98	39.8	61.6	0.0064
BC2	BF	LaCygne	20	6.1	4.82	7.84	3.29	42.0	61.5	0.0058
				5.6	4.24	7.07	2.84	40.2	59.9	0.0061
				5.8	4.53	7.46	3.07	41.1	60.7	0.0060
BC3	BF	LaCygne	30	5.8	4.25	7.11	3.63	51.1	59.7	0.0048
				6.0	5.13	8.24	3.65	44.3	62.2	0.0050
				5.9	4.69	7.68	3.64	47.7	60.9	0.0049

Table 5 (Continued)

LINEAR TRAVERSE DATA

Beam Set	Coarse Aggr	Fly Ash Source	Pct Cem Repl	Percent Air: Fresh Conc All Bbls	Percent Air: Hardened Conc All Bbls	Percent Air: Hardened Mortar All Bbls	Percent Air: Hardened Mortar Bbls (1)	Percent Bbls (1)	Percent Mortar	Spac Fact
BD1	BF	Nearman	10	6.1	4.11	6.83	3.32	48.6	60.2	0.0050
				5.8	4.19	6.63	3.34	50.4	63.1	0.0054
				6.0	4.15	6.73	3.33	49.5	61.6	0.0052
BD2	BF	Nearman	20	6.1	4.99	8.31	3.53	42.4	60.1	0.0055
				6.1	4.86	7.63	3.74	49.0	63.8	0.0048
				6.1	4.93	7.97	3.64	45.7	61.9	0.0052
BD3	BF	Nearman	30	5.7	5.23	9.02	3.57	39.6	57.9	0.0056
				5.6	5.19	8.85	3.06	34.6	58.6	0.0059
				5.6	5.21	8.94	3.32	37.1	58.3	0.0058
BNO	BF	None	0	5.6	5.62	9.19	3.07	33.4	61.1	0.0066
				5.7	4.78	8.04	3.28	40.8	59.5	0.0057
				5.7	5.20	8.62	3.18	37.1	60.3	0.0062
PA1	Plat	Joliet	10	6.1	5.36	8.51	3.52	41.3	62.9	0.0059
				5.8	4.36	7.09	3.22	45.5	61.5	0.0055
				6.0	4.86	7.80	3.37	43.4	62.3	0.0057
PA2	Plat	Joliet	20	5.8	4.83	8.21	3.44	41.9	58.8	0.0055
				5.6	5.15	8.46	3.51	41.5	60.8	0.0053
				5.7	4.99	8.34	3.48	41.7	59.8	0.0054
PA3	Plat	Joliet	30	5.7	4.65	8.47	3.62	42.8	54.8	0.0052
				6.4	4.87	8.27	3.88	46.9	58.9	0.0045
				6.1	4.76	8.37	3.75	44.9	56.9	0.0049
PNO	Plat	None	0	5.8	4.36	7.55	3.19	42.3	57.8	0.0059
				5.8	3.95	7.41	3.11	42.0	53.3	0.0055
				5.8	4.15	7.48	3.15	42.2	55.5	0.0057

(1) Less than 0.0060 inch chord length.

Table 6

CHARACTERISTICS OF FLY ASH

Chemical Properties

Property	ASTM C618	A	B	C	D
$SiO_2+Al_2O_3+Fe_2O_3$, %	50.0 Min	73.98	62.63	59.51	56.57
SO_3, %	5.0 Max	1.26	2.02	2.52	3.44
Moisture, %	3.0 Max	0.03	0.0	0.0	0.0
Loss on ign, %	6.0 Max	0.31	0.30	0.54	0.50
Avail Alk, Na_2O, %	1.50 Max*	2.07	1.18	0.96	1.38
CaO, %	- -	13.25	25.78	28.70	29.62
MgO, %	- -	3.73	4.96	4.94	6.23

Physical Properties

Property	ASTM C618	A	B	C	D
Plus 325, %	34 Max	13.2	14.8	31.0	10.8
Pozz Activity, %	75 Min	95	95.5	76.2	102.0
Water, % of Std	105 Max	88	89	94	87
Specific Surface	- -	3820	3605	2840	4180
Unit Weight, Dry	- -	75	80	77	72
Specific Gravity	- -	2.512	2.649	2.663	2.770

* Applies only when using reactive aggregates

Table 7

Compressive Strength and Setting Time of Mortar

Fly Ash Source	Pct Cem Repl	Compressive Strength 6 h	1 d	3 d	7 d	28 d	56 d	Setting Time Init	Final
Joliet	10	30	1655	3230	3865	5830	6486	3:50	5:35
Joliet	20	30	1340	2875	3575	5585	6680	4:00	5:45
Joliet	30	15	1235	2765	3395	5600	6945	4:25	6:40
Iatan	10	45	1545	2970	4025	5990	6490	3:50	5:35
Iatan	20	25	1360	2915	3785	6005	6695	4:25	6:55
Iatan	30	15	1035	2570	3585	5070	6040	4:30	8:10
LaCygne	10	40	1485	2885	3630	5440	5950	3:20	5:10
LaCygne	20	30	1335	2885	3445	5360	6000	3:55	5:55
LaCygne	30	10	1110	2350	3215	4835	5590	4:00	6:35
Nearman	10	40	1805	3345	4300	5820	6535	3:20	5:15
Nearman	20	35	1725	3235	4200	5855	6255	2:40	5:30
Nearman	30	25	1560	3405	4330	6090	6470	1:40	5:35
None	0			3290	4190			3:00	4:20

Table 8

Setting Time of Mortar From a Separate Study

Fly Ash Source	Fly Ash Class	Pct Cem Repl	Mo. Portland Cement Setting Time		Dundee Cement Setting Time		Monarch Cement Setting Time	
			Init	Final	Init	Final	Init	Final
Montrose	F	10	3:13	5:03	3:45	5:45	4:01	6:06
Montrose	F	20	3:33	5:33	3:44	5:49	4:05	6:15
Montrose	F	30	3:42	6:32	3:54	6:34	4:15	6:50
Montrose	F	40	3:47	7:03	3:23	6:58	4:30	7:10
Montrose	F	100	30:00+	No Set	30:00+	No Set	30:00+	No Set
Iatan	C	10	3:16	5:11	3:52	5:42	4:17	6:17
Iatan	C	20	3:45	6:10	4:18	6:48	4:30	6:45
Iatan	C	30	4:15	6:40	4:06	6:56	4:35	7:35
Iatan	C	40	3:00	7:00	3:12	7:32	3:05	8:00
Iatan	C	100	0:07	0:12	0:07	0:12	0:07	0:12
LaCygne	C	10	3:18	5:48	3:48	6:33	4:05	6:20
LaCygne	C	20	1:47	7:12	2:13	7:38	2:15	7:25
LaCygne	C	30	1:15	7:15	1:10	7:47	1:25	7:20
LaCygne	C	40	0:50	3:25	0:45	2:27	0:45	3:50
LaCygne	C	100	0:00	Set Fast	0:00	Set Fast	0:00	Set Fast
Nearman	C	10	3:10	6:00	3:23	5:33	3:50	6:05
Nearman	C	20	2:42	5:52	2:30	6:10	2:49	6:09
Nearman	C	30	1:23	5:03	2:03	6:08	2:34	6:14
Nearman	C	40	0:40	5:10	1:02	6:07	1:13	6:08
Nearman	C	100	0:05	0:18	0:05	0:18	0:05	0:18
None		0	3:25	5:10	3:30	5:25	3:50	5:20

RD LIBRARY
RD0009214