Blended Cement Patching Research

Final Report
for
MLR-04-01

March 2005

Highway Division

Iowa Department Of Transportation

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TECHNICAL REPORT TITLE PAGE

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8. ABSTRACT

With the recent introduction of blended cements, many ready mix producers are using them as their sole source of cement. Iowa DOT specifications currently do not allow blended cements in patching due to their assumed slower strength gain. Patching specifications require opening at 5 hours on 2-lane or 10 hours on 4-lane pavement.

This research will investigate early strength of concrete cast with ordinary Type I/II Portland cements and Type I(SM) blended Portland cements.

The conclusions of this research are as follows:

1. Obtaining opening strength (5-hour patch) using Type I(SM) cement may be achieved by either 1) allowing one-half hour to one hour longer cure time, depending on ambient temperature or 2) using an increased dosage of mid range water reducer to achieve a lower w/c ratio.
2. Adequate strength is reached at 10 hours when Type I/II or Type I(SM) cements are used.

The following recommendations are based on conclusions from this research:

1. Allow use of Type I(SM) cement for 5 hour patches provided a Type A mid range water reducer is used at a higher rate to achieve a reduction in w/c ratio of at least 0.02 over the same mix with Type I or I/II cement.
2. Allow use of Type I(SM) for 10 hour patches without fly ash replacement.
3. Require longer curing time of at least 6 hours when Type I(SM) is used for patching when ambient temperatures are below 55 ºF.
4. Require use of a Type A water reducer for all patching.

9. KEY WORDS	10. NO. OF PAGES
Blended cement Patching	13

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DISCLAIMER

The contents of this report reflect the views of the author(s) and do not necessarily reflect the official views or policy of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.

Introduction and Objective

With the recent introduction of blended cements, many ready mix producers are using them as their sole source of cement. Iowa DOT specifications currently do not allow blended cements in patching due to their assumed slower strength gain. Patching specifications require opening at 5 hours on 2-lane or 10 hours on 4-lane pavement.

This research will investigate early strength of concrete cast with ordinary Type I/II Portland cements and Type I(SM) blended Portland cements.

Materials

The following materials were used in this research:

Cements	Admixtures
Lafarge I/II	WRDA 82
Lafarge I(SM)	MIRA 92
Holcim I	
Holcim I(SM)	

Ft. Dodge limestone and Cordova sand was used with an M-4 mix design with CaCl. The mix design batch weights are included in Figures 1-3 of the Appendix.

CaCl solution, made with 77% flake CaCl, was added at the rate of 2.75 gallons per cubic yard. The CaCl solution produces 1.35 gallons per 1 gallon of water.

Testing

An M-4 mix design with CaCl solution was batched for each cement type. Initial testing indicated a reduction in slump after CaCl solution was added. A second mix was batched and a normal Type A water reducer was added resulting in an increase in slump and air. A normal Type A water reducer was then used in the first four mixes.

Since slump was reduced after the CaCl solution was added, it was decided to increase slump and minimize the water cement ratio by use of either a Type A mid-range water reducer at a higher dosage rate or a Type F high range water reducer. The mid-range water reducer was used to ensure adequate control of air content during field placement.

Nine cylinders were cast for testing at 5, 7 and 24 hours. Specimens were placed in the Blue M humidity cabinet and cure was accelerated from 85 °F for the first 2 hours, 105 °F for the next 2 hours, 125 °F for 3 hours, and then allowed to return slowly to the 75 °F. Cylinder temperatures for each mix are shown in Figure 4 of the Appendix. This accelerated cure was applied to replicate the temperatures in a patch as shown in previous research[1]. Results of the concrete testing for each mix were as follows:

Cement	Water Reducer	Air, %	Slump, inches	w/c	Compressive Strength, psi		
					5 hr	7 hr	24 hr
Lafarge I/II	WRDA-82	6.0	1.50	0.371	2180	3250	5220
Lafarge I(SM)	WRDA-82	5.8	2.75	0.354	1870	2940	5010
Holcim I	WRDA-82	7.2	2.00	0.377	2230	3840	5950
Holcim I(SM)	WRDA-82	6.2	1.75	0.365	1680	3000	5230
Holcim I(SM)	MIRA-92	5.5	3.75	0.353	2130	3380	5400
Lafarge I(SM)	MIRA-92	5.5	2.75	0.343	2490	3710	5560

Results and Discussion

The results indicate the Type I(SM) cements achieve slightly lower strengths at 5 hours than the Type I cements. At 10 hours the Type I(SM) cements are still slightly lower in strength, but are more than adequate for opening patches. [1]

Use of the maturity spreadsheet, which performs a linear regression between strength and TTF, tended to over estimate strength at 5 hours. Maturity graphs are shown in Figures 5-10 in the Appendix. Since the specification is based on time only, the compressive strengths were plotted versus the log of time. These plots are shown Figures 11-13 in Appendix. At the curing temperatures in this research, the difference in time to achieve the same strength with Type I(SM) and Type I/II cement is approximately one-half hour.

Use of the Type A mid range water reducer allowed a slightly lower w/c ratio (approximately 0.01) for both Type I(SM) cements and achieved slightly higher slump. This resulted in an increased compressive strength at 5 hours.

Conclusions and Recommendations

The conclusions of this research are as follows:

1. Obtaining opening strength (5-hour patch) using Type I(SM) cement may be achieved by either 1) allowing one-half hour to one hour longer cure time, depending on ambient temperature or 2) using an increased dosage of mid range water reducer to achieve a lower w/c ratio.
2. Adequate strength is reached at 10 hours when Type I/II or Type I(SM) cements are used.

The following recommendations are based on conclusions from this research:

1. Allow use of Type I(SM) cement for 5 hour patches provided a Type A mid range water reducer is used at a higher rate to achieve a reduction in w/c ratio of at least 0.02 over the same mix with Type I or I/II cement.
2. Allow use of Type I(SM) for 10 hour patches without fly ash replacement.
3. Require longer curing time of at least 6 hours when Type I(SM) is used for patching when ambient temperatures are below 55 ºF.
4. Require use of a Type A water reducer for all patching.

Acknowledgement

The authors would like to thank Mike Coles, Leroy Lutjen, and Ken Kennedy from the Cement and Concrete Section for their help in this research.

References

1. Narotam, Champ and Vu, John, MLR-93-7, Evaluation of Concrete Patching Mixes and Opening Time using the Maturity Concept, November 1993

Appendix

Figure 1 - Type I/II Mix Design with WR

GENERAL INFORMATION

PROJECT:		0
PROJECT TITLE:	Patch Research	
MIX TYPE:		0
MIX NUMBER:	M-4 CACL	
DATE:	1/0/1900	

MATERIALS	*Source*	*Type/Class*	*SPG*	*Percent*	*Percent*
CEMENT:	Holcim & Lafarge	I & I/II	3.14		
FLY ASH:				0.00	
MINERAL ADMIXTURE:				0.00	
SILICA FUME SLURRY:				0.00	
FINE AGGREGATE:	Cordova		2.67	50.00	
COARSE AGGREGATE:	Ft. Dodge		2.66	50.00	100.00
INTERMEDIATE AGGREGATE:				0.00	0.00
AIR ENTRAINING AGENT:	Daravair 1400				
RETARDER:					
WATER REDUCER:	WRDA82				
SUPER WATER REDUCER:					
ACCELERATOR:					
DESIGN W/C(+FLY ASH):	0.33				
DESIGN SLUMP:	4.0				
DESIGN AIR CONTENT:	6.0				

QUANTITIES (absolute volume method in SSD condition)

	Volume ft3 Batch Size 1.0 yd3	Volume ft3 Batch Size 1.0 ft3						Weight lbs Batch Size 1.0 ft3	Weight lbs Batch Size 1.0 yd3	Weight lbs Lab Batch Size 0.75
CEMENT:	4.2120	0.1560	X	3.14	X	62.4	=	30.6	825	22.9
FLY ASH:	0.0000	0.0000						0.0	0	0.0
MINERAL ADMIXTURE:	0.0000	0.0000						0.0	0	0
SILICA FUME SLURRY:	0.0000	0.0000						0.0	0	0
WATER:	4.3645	0.1616	X	1.00	X	62.4	=	10.1	272	7.6
FINE AGGREGATE:	8.4018	0.3112	X	2.67	X	62.4	=	51.8	1400	38.9
COARSE AGGREGATE:	8.4018	0.3112	X	2.66	X	62.4	=	51.7	1395	38.7
INTERMEDIATE AGGREGATE:	0.0000	0.0000						0.0	0	0.0
AIR:	1.6200	0.0600	X	0.00	X	62.4	=	0.0	0	0.0
Summation	**27.0000**	**1.0000**						**144.1**	**3892**	**108.1**
Paste Content	**31.8**									
Mortar Content (abs vol)	**68.9**									
Mortar Content (% pass)	**37.8**									

CHEMICAL ADMIXTURES

	Rate oz/100 lbs cementitious							Rate ml Batch Size 1.0 ft3	Rate ml Batch Size 1.0 yd3	Rate ml Lab Batch Size 0.8
AIR ENTRAINING AGENT:	0.6	30.57	X	0.006	X	29.57	=	5.4	146.4	4.1
RETARDER:										
WATER REDUCER:	3.5	30.57	X	0.035	X	29.57	=	31.6	854.1	23.7
SUPER WATER REDUCER:										
ACCELERATOR:										

Figure 2 - Type I(SM) Mix Design with WR

GENERAL INFORMATION

PROJECT:		0
PROJECT TITLE:	Patch Research	
MIX TYPE:		0
MIX NUMBER:	M-4 CACL	
DATE:	1/0/1900	

MATERIALS	*Source*	*Type/Class*	*SPG*	*Percent*	*Percent*
CEMENT:	Holcim & Lafarge	I(SM)	3.1		
FLY ASH:				0.00	
MINERAL ADMIXTURE:				0.00	
SILICA FUME SLURRY:				0.00	
FINE AGGREGATE:	Cordova		2.67	50.00	
COARSE AGGREGATE:	Ft. Dodge		2.66	50.00	100.00
INTERMEDIATE AGGREGATE:				0.00	0.00
AIR ENTRAINING AGENT:	Daravair 1400				
RETARDER:					
WATER REDUCER:	WRDA82				
SUPER WATER REDUCER:					
ACCELERATOR:					
DESIGN W/C(+FLY ASH):	0.33				
DESIGN SLUMP:	4.0				
DESIGN AIR CONTENT:	6.0				

QUANTITIES (absolute volume method in SSD condition)

	Volume ft3 Batch Size 1.0 yd3	Volume ft3 Batch Size 1.0 ft3						Weight lbs Batch Size 1.0 ft3	Weight lbs Batch Size 1.0 yd3	Weight lbs Lab Batch Size 0.75
CEMENT:	4.2120	0.1560	X	3.10	X	62.4	=	30.2	815	22.6
FLY ASH:	0.0000	0.0000						0.0	0	0.0
MINERAL ADMIXTURE:	0.0000	0.0000						0.0	0	0
SILICA FUME SLURRY:	0.0000	0.0000						0.0	0	0
WATER:	4.3089	0.1596	X	1.00	X	62.4	=	10.0	269	7.5
FINE AGGREGATE:	8.4296	0.3122	X	2.67	X	62.4	=	52.0	1404	39.0
COARSE AGGREGATE:	8.4296	0.3122	X	2.66	X	62.4	=	51.8	1399	38.9
INTERMEDIATE AGGREGATE:	0.0000	0.0000						0.0	0	0.0
AIR:	1.6200	0.0600	X	0.00	X	62.4	=	0.0	0	0.0
Summation	**27.0000**	**1.0000**						**144.0**	**3887**	**108.0**
Paste Content	**31.6**									
Mortar Content (abs vol)	**68.8**									
Mortar Content (% pass)	**37.6**									

CHEMICAL ADMIXTURES

	Rate oz/100 lbs cementitious							Rate ml Batch Size 1.0 ft3	Rate ml Batch Size 1.0 yd3	Rate ml Lab Batch Size 0.8
AIR ENTRAINING AGENT:	0.6	30.18	X	0.006	X	29.57	=	5.4	144.6	4.0
RETARDER:										
WATER REDUCER:	3.5	30.18	X	0.035	X	29.57	=	31.2	843.2	23.4
SUPER WATER REDUCER:										
ACCELERATOR:										

Figure 3 – Type I(SM) Mix Design with Mid Range WR

GENERAL INFORMATION

PROJECT:		0
PROJECT TITLE:	Patch Research	
MIX TYPE:		0
MIX NUMBER:	M-4 CACL	
DATE:	1/0/1900	

MATERIALS	*Source*	*Type/Class*	*SPG*	*Percent*	*Percent*
CEMENT:	Lafarge/Holcim	I(SM)	3.1		
FLY ASH:				0.00	
MINERAL ADMIXTURE:				0.00	
SILICA FUME SLURRY:				0.00	
FINE AGGREGATE:	Cordova		2.67	50.00	
COARSE AGGREGATE:	Ft. Dodge		2.66	50.00	100.00
INTERMEDIATE AGGREGATE:				0.00	0.00
AIR ENTRAINING AGENT:	Daravair 1400				
RETARDER:					
WATER REDUCER:	MIRA 92				
SUPER WATER REDUCER:					
ACCELERATOR:					
DESIGN W/C(+FLY ASH):	0.33				
DESIGN SLUMP:	4.0				
DESIGN AIR CONTENT:	6.0				

QUANTITIES (absolute volume method in SSD condition)

	Volume ft3 Batch Size 1.0 yd3	Volume ft3 Batch Size 1.0 ft3						Weight lbs Batch Size 1.0 ft3	Weight lbs Batch Size 1.0 yd3	Weight lbs Lab Batch Size 0.75
CEMENT:	4.2120	0.1560	X	3.10	X	62.4	=	30.2	815	22.6
FLY ASH:	0.0000	0.0000						0.0	0	0.0
MINERAL ADMIXTURE:	0.0000	0.0000						0.0	0	0
SILICA FUME SLURRY:	0.0000	0.0000						0.0	0	0
WATER:	4.3089	0.1596	X	1.00	X	62.4	=	10.0	269	7.5
FINE AGGREGATE:	8.4296	0.3122	X	2.67	X	62.4	=	52.0	1404	39.0
COARSE AGGREGATE:	8.4296	0.3122	X	2.66	X	62.4	=	51.8	1399	38.9
INTERMEDIATE AGGREGATE:	0.0000	0.0000						0.0	0	0.0
AIR:	1.6200	0.0600	X	0.00	X	62.4	=	0.0	0	0.0
Summation	**27.0000**	**1.0000**						**144.0**	**3887**	**108.0**
Paste Content	**31.6**									
Mortar Content (abs vol)	**68.8**									
Mortar Content (% pass)	**37.6**									

CHEMICAL ADMIXTURES

	Rate oz/100 lbs cementitious							Rate ml Batch Size 1.0 ft3	Rate ml Batch Size 1.0 yd3	Rate ml Lab Batch Size 0.8
AIR ENTRAINING AGENT:	0.6	30.18	X	0.006	X	29.57	=	5.4	144.6	4.0
RETARDER:										
WATER REDUCER:	6.0	30.18	X	0.06	X	29.57	=	53.5	1445.6	40.2
SUPER WATER REDUCER:										
ACCELERATOR:										

Figure 4 – Temperature Profile in Cylinders

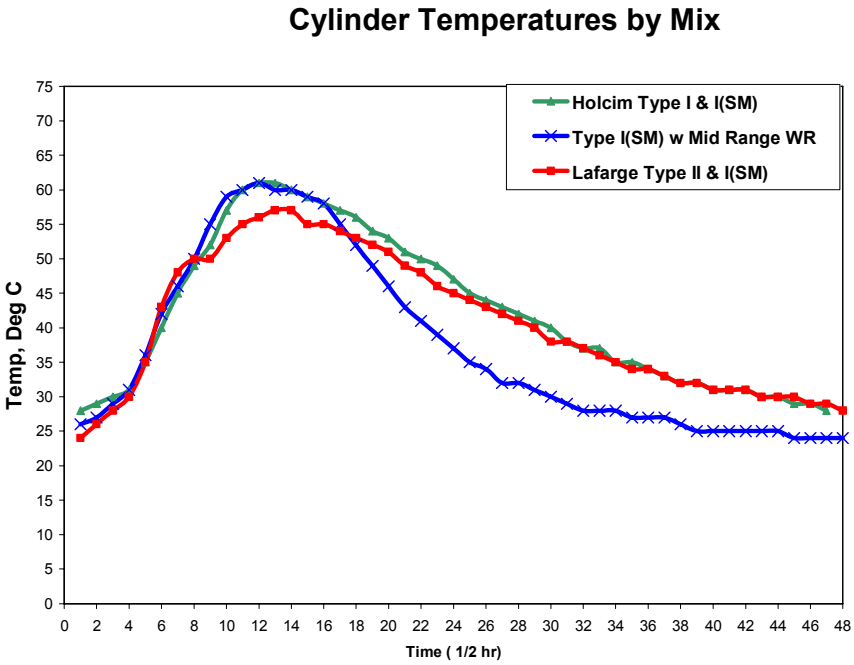


Figure 5 – Maturity Curve Holcim Type I

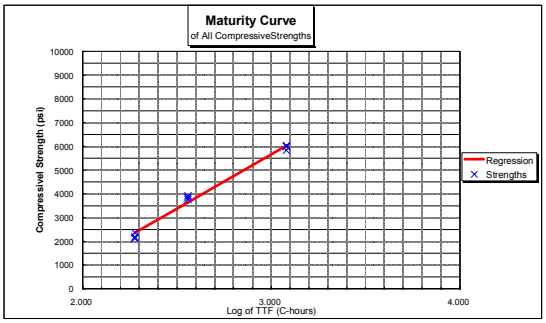
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT Holcim I

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		Enter	Enter		Enter	Enter	Enter		Enter
1	27580		8.00	4.00	2190	5	189	189	189	57
2	26670		8.00	4.00	2120	5	189	189	189	57
3	29740		8.00	4.00	2370	5	189	189	189	57
4	49303		8.00	4.00	3920	7	362	362	362	60
5	47286		8.00	4.00	3760	7	362	362	362	60
6	48306		8.00	4.00	3840	7	362	362	362	60
7	73331		8.00	4.00	5840	24	1205	1205	1205	28
8	75342		8.00	4.00	6000	24	1205	1205	1205	28
9	75761		8.00	4.00	6030	24	1205	1205	1205	28
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	Enter
AIR:	6
SLUMP:	1.5"
w/c:	0.38
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Holcim I
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	WRDA 82
Add. Rate:	3.5 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	158



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 6 – Maturity Curve Holcim Type I(SM)

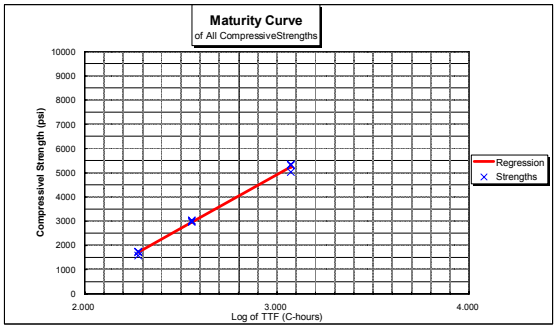
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT Holcim I(SM)

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		Enter	Enter		Enter	Enter	Enter		Enter
1	19970		8.00	4.00	1590	5	190	190	190	56
2	21550		8.00	4.00	1710	5	190	190	190	56
3	21930		8.00	4.00	1750	5	190	190	190	56
4	37153		8.00	4.00	2960	7	361	361	361	59
5	37782		8.00	4.00	3010	7	361	361	361	59
6	38151		8.00	4.00	3040	7	361	361	361	59
7	66790		8.00	4.00	5310	24	1182	1182	1182	28
8	63230		8.00	4.00	5030	24	1182	1182	1182	28
9	67223		8.00	4.00	5350	24	1182	1182	1182	28
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	Enter
AIR:	5.8
SLUMP:	2.75"
w/c:	0.37
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Holcim I(SM)
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	WRDA 82
Add. Rate:	3.5 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	220



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 7 – Maturity Curve Lafarge Type I/II

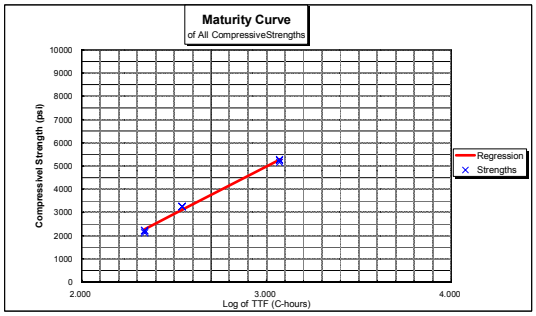
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT LAFARGE I/II

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		*Enter*	*Enter*		*Enter*	*Enter*	*Enter*		*Enter*
1	26650		8.00	4.00	2120	5	219	219	219	53
2	27650		8.00	4.00	2200	5	219	219	219	53
3	28050		8.00	4.00	2230	5	219	219	219	53
4	40781		8.00	4.00	3250	7	350	350	350	56
5	40796		8.00	4.00	3250	7	350	350	350	56
6	41027		8.00	4.00	3260	7	350	350	350	56
7	66210		8.00	4.00	5270	24	1176	1176	1176	28
8	65820		8.00	4.00	5240	24	1176	1176	1176	28
9	64817		8.00	4.00	5160	24	1176	1176	1176	28
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	*Enter*
AIR:	7.2
SLUMP:	2"
w/c:	0.36
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Lafarge I/II
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	WRDA 82
Add. Rate:	3.5 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	187



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 8 – Maturity Curve Lafarge Type I(SM)

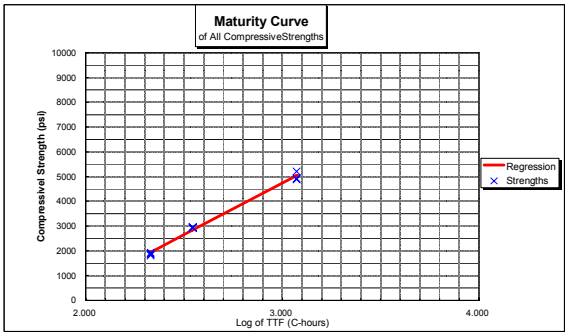
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT LAFARGE I(SM)

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		*Enter*	*Enter*		*Enter*	*Enter*	*Enter*		*Enter*
1	22790		8.00	4.00	1810	5	214	214	214	54
2	23470		8.00	4.00	1870	5	214	214	214	54
3	24150		8.00	4.00	1920	5	214	214	214	54
4	36980		8.00	4.00	2940	7	350	350	350	57
5	36664		8.00	4.00	2920	7	350	350	350	57
6	37200		8.00	4.00	2960	7	350	350	350	57
7	62010		8.00	4.00	4930	24	1179	1179	1179	29
8	61415		8.00	4.00	4890	24	1179	1179	1179	29
9	65447		8.00	4.00	5210	24	1179	1179	1179	29
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	*Enter*
AIR:	5.8
SLUMP:	2.75"
w/c:	0.37
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Lafarge I(SM)
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	WRDA 82
Add. Rate:	3.5 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	221



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 9 – Maturity Curve Holcim Type I(SM) with Mid Range Water Reducer

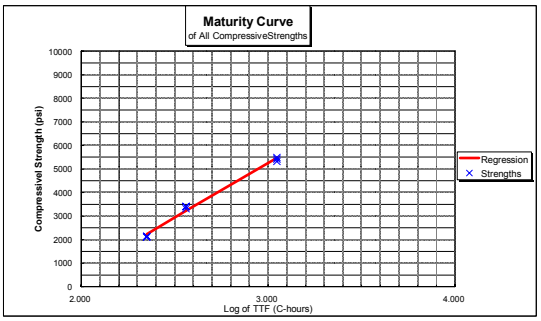
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT Holcim I(SM)

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		Enter	Enter		Enter	Enter	Enter		Enter
1	26425		8.00	4.00	2100	5	224	224	224	59
2	26730		8.00	4.00	2130	5	224	224	224	59
3	27020		8.00	4.00	2150	5	224	224	224	59
4	41620		8.00	4.00	3310	7	364	364	364	60
5	42820		8.00	4.00	3410	7	364	364	364	60
6	42840		8.00	4.00	3410	7	364	364	364	60
7	68100		8.00	4.00	5420	24	1113	1113	1113	24
8	68981		8.00	4.00	5490	24	1113	1113	1113	24
9	66793		8.00	4.00	5320	24	1113	1113	1113	24
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	Enter
AIR:	5.5
SLUMP:	3.75
w/c:	0.353
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Holcim I(SM)
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	WRDA 82
Add. Rate:	3.5 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	199



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 10 – Maturity Curve Lafarge Type I(SM) with Mid Range Water Reducer

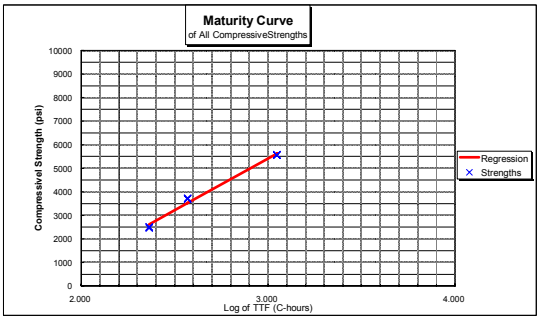
MATURITY - COMPRESSIVE STRENGTH DEVELOPMENT LAFARGE I(SM)

COUNTY: _____ **CURVE #:** _____ **PROJ. #:** _____ **MONITOR:** _____ **REP/CONTRACTOR:** _____ **INSPECTOR:** _____ **DATE:** _____

BEAM #	LOAD AT BREAK (lbs)	BREAK Type	Length (in)	Diameter (in)	Compressive STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF	Cylinder TEMP (AVG)
	Enter		Enter	Enter		Enter	Enter	Enter		Enter
1	30790		8.00	4.00	2450	5	231	231	231	57
2	31530		8.00	4.00	2510	5	231	231	231	57
3	31380		8.00	4.00	2500	5	231	231	231	57
4	46410		8.00	4.00	3690	7	371	371	371	59
5	46610		8.00	4.00	3710	7	371	371	371	59
6	46930		8.00	4.00	3730	7	371	371	371	59
7	69734		8.00	4.00	5550	24	1113	1113	1113	24
8	70120		8.00	4.00	5580	24	1113	1113	1113	24
9	69747		8.00	4.00	5550	24	1113	1113	1113	24
10			8.00	4.00	0				0	
11			8.00	4.00	0				0	
12			8.00	4.00	0				0	

MIX INFORMATION	Enter
AIR:	5.5
SLUMP:	2.75"
w/c:	0.343
MIX:	M-4 CaCl
FLY ASH SOURCE:	
CEMENT SOURCE:	Lafarge I(SM)
COARSE AGGREGATE SOURCE:	Ft Dodge
FINE AGGREGATE SOURCE:	Cordova
WATER REDUCER BRAND:	MIRA 92
Add. Rate:	6 oz / cwt
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	0.6oz / cwt
METHOD OF DEVELOPMENT:	Maturity Meter
DESIRED COMP. STRENGTH (psi):	2000 psi

REQUIRED TTF:	167



Certified Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

cc: RCE, DME, Central Materials, Contractor

Figure 11 – Time versus Compressive Strength Holcim Cements

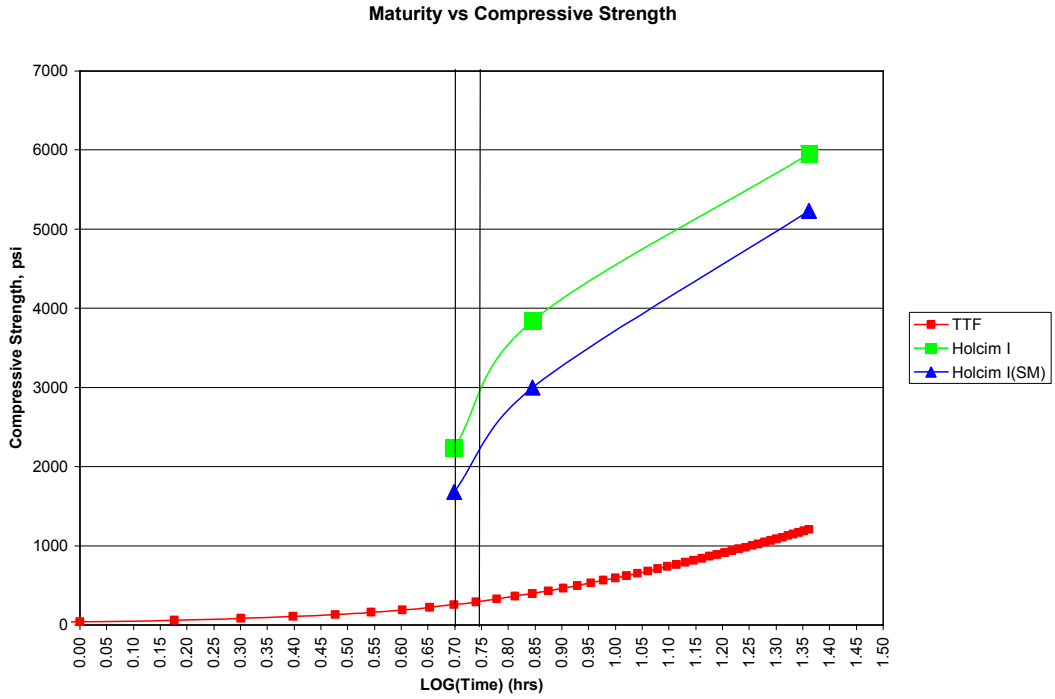


Figure 12 – Time versus Compressive Strength Lafarge Cements

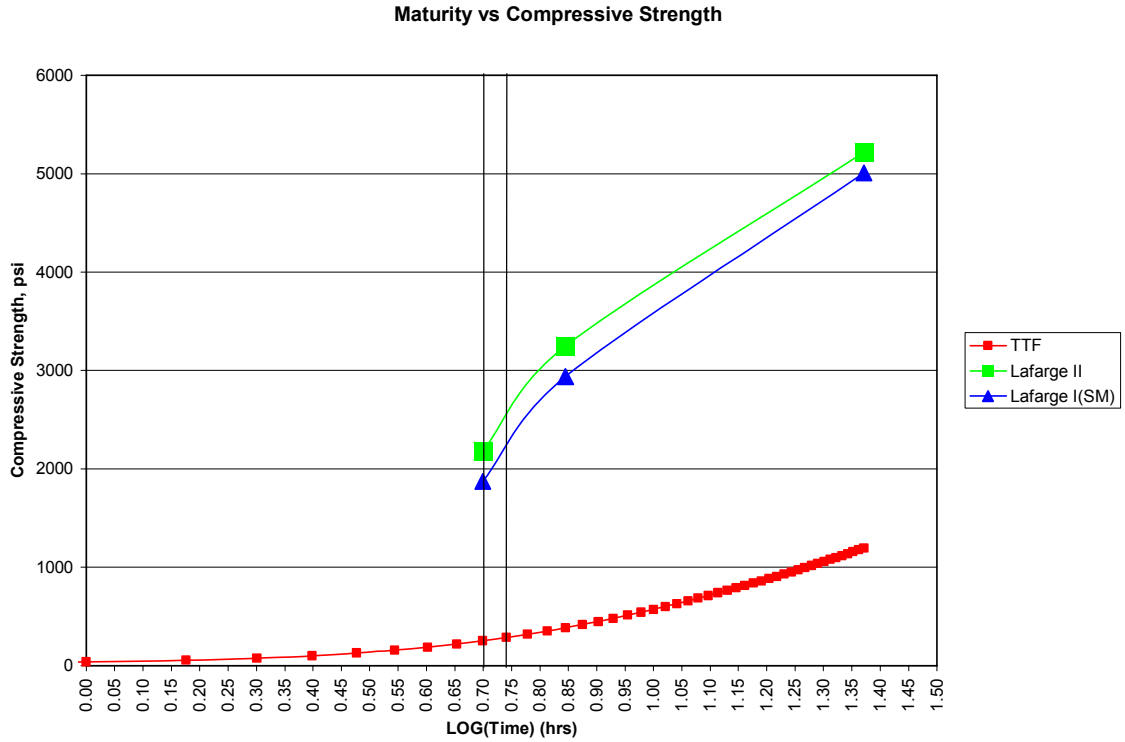


Figure 13 – Time versus Compressive Strength Type I(SM) Cements w Mid Range WR