

# Mitigating & Managing Alkali-Silica Reactivity (ASR) in the Future

*Moving Massachusetts Forward.*  
**massDOT**



**Massachusetts Department of Transportation**

The 90<sup>th</sup> Annual Meeting of the North East States Materials Engineers Association

Richard F. Mulcahy, EIT

21-22 October 2014

# The Prescription for ASR?

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# The Prescription for ASR?

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- ✓ FLY ASH
- ✓ SLAG
- ✓ SILICA FUME
- ✓ LITHIUM
- ✓ LOW ALKALI CEMENT
- ✓ NON-REACTIVE AGGREGATE



# LONG-TERM EXPOSURE SITE STUDY

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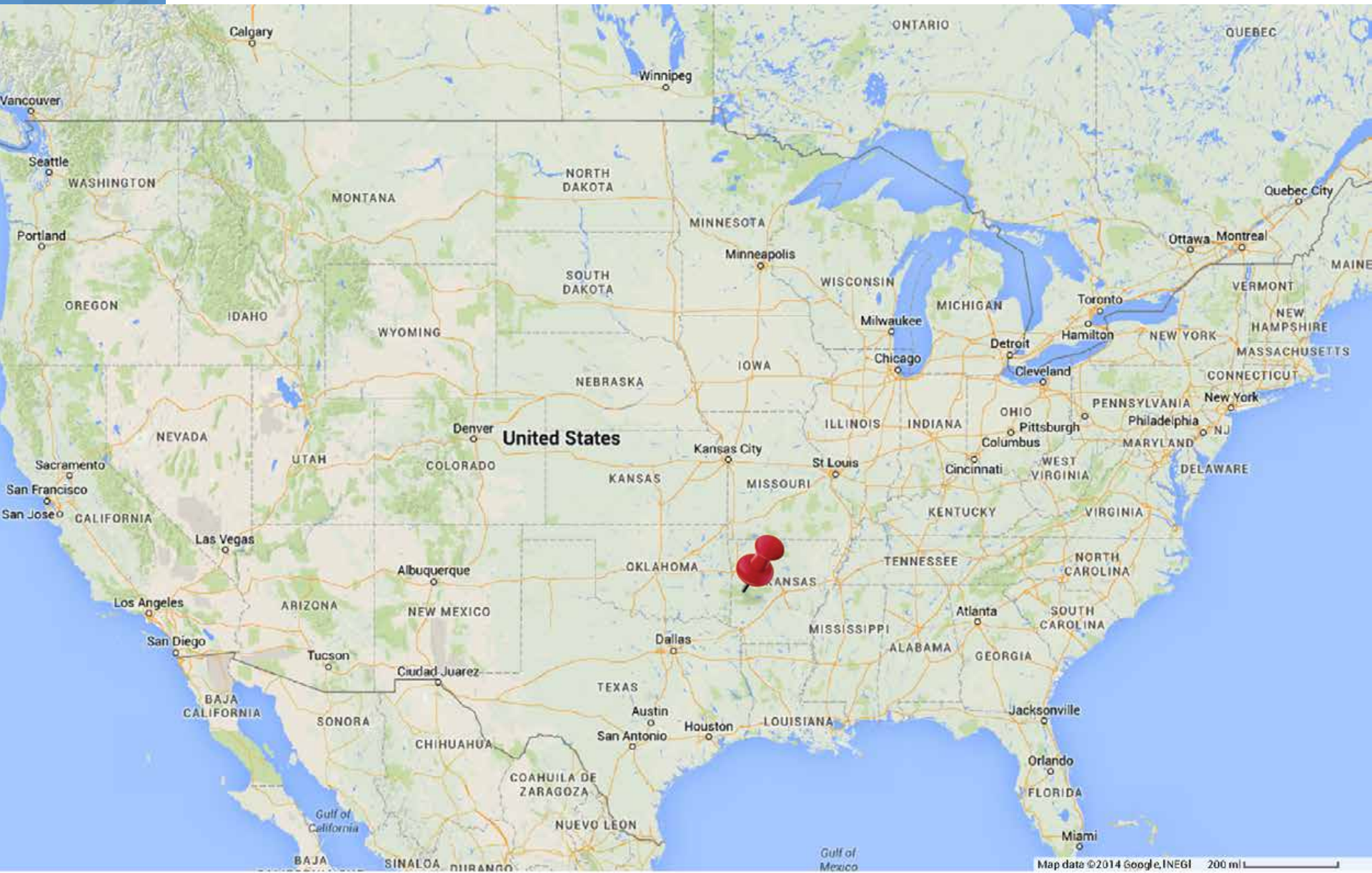
*Report on Determining the Reactivity of Concrete Aggregates and  
Selecting Appropriate Measures for Preventing Deleterious  
Expansion in New Concrete Construction*



U.S. Department of Transportation  
Federal Highway Administration



# LONG-TERM EXPOSURE SITE STUDY























2.6  
RC



# PURPOSE

# LONG-TERM EXPOSURE SITE STUDY

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✓ SIMULATE



✓ CORRELATE



✓ PRESCRIBE



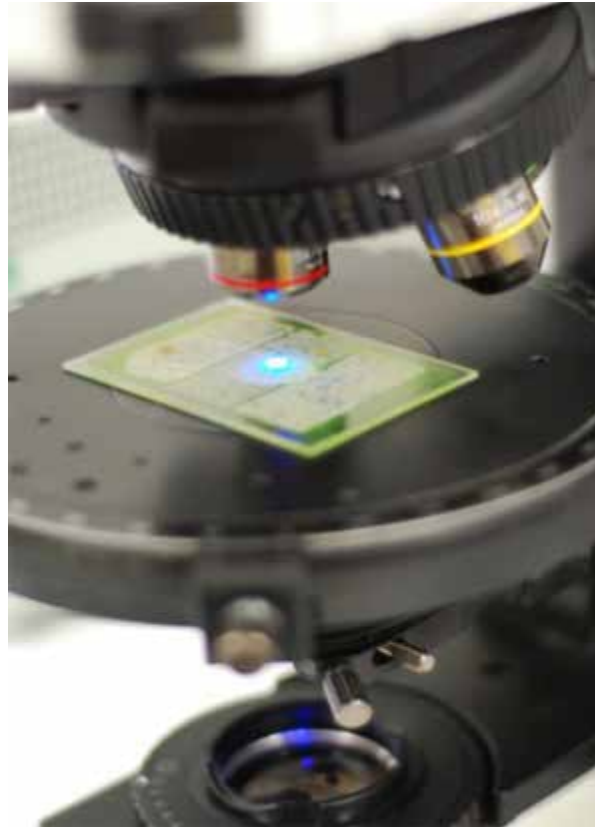


# LABORATORY TESTING

## LONG-TERM EXPOSURE SITE STUDY

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### ✓ ASTM C295 PETROGRAPHIC EXAMINATION





## LONG-TERM EXPOSURE SITE STUDY

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- ✓ AASHTO T303 MORTAR BAR TEST (14 DAYS)



# LONG-TERM EXPOSURE SITE STUDY

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- ✓ ASTM C1293 CONCRETE PRISM TEST (1-2 YRS)





# LONG TERM EXPOSURE SITE STUDY

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# MIX DESIGNS

# LONG TERM EXPOSURE SITE STUDY

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## ✓ NON-REACTIVE MIXES

BLOCK	AGG	Na <sub>2</sub> Oe	CEM	FA	SLAG	SF	LITHIUM
50	1	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
26	2	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
39	7	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
51	1	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
27	2	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
40	7	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
28	2	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
41	7	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%

# LONG TERM EXPOSURE SITE STUDY

## ✓ MODERATELY REACTIVE MIXES

BLOCK	AGG	Na <sub>2</sub> Oe	CEM	FA	SLAG	SF	LITHIUM
1	3	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
42	8	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
11	9	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
2	3	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
43	8	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
12	9	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
72	3	0.88%	65.0%	0.0%	35.0%	0.0%	0.0%
73	3	0.88%	50.0%	0.0%	50.0%	0.0%	0.0%
70	3	0.88%	80.0%	20.0%	0.0%	0.0%	0.0%
71	3	0.88%	70.0%	30.0%	0.0%	0.0%	0.0%
3	3	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
44	8	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
13	9	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
14	9	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
49	UT3	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
10	3	1.10%	100.0%	0.0%	0.0%	0.0%	100.0%
9	3	1.10%	76.0%	0.0%	20.0%	4.0%	0.0%
6	3	1.10%	65.0%	0.0%	35.0%	0.0%	0.0%
7	3	1.10%	50.0%	0.0%	50.0%	0.0%	0.0%
8	3	1.10%	81.0%	15.0%	0.0%	4.0%	0.0%
4	3	1.10%	80.0%	20.0%	0.0%	0.0%	0.0%
5	3	1.10%	70.0%	30.0%	0.0%	0.0%	0.0%



# LONG TERM EXPOSURE SITE STUDY

## ✓ HIGHLY REACTIVE MIXES

BLOCK	AGG	Na <sub>2</sub> Oe	CEM	FA	SLAG	SF	LITHIUM
45	4	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
29	10	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
46	4	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
30	10	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
47	4	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
31	10	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
38	10	1.10%	100.0%	0.0%	0.0%	0.0%	100.0%
35	10	1.10%	65.0%	0.0%	35.0%	0.0%	0.0%
32	10	1.10%	50.0%	0.0%	50.0%	0.0%	0.0%
36	10	1.10%	81.0%	15.0%	0.0%	4.0%	0.0%
33	10	1.10%	80.0%	20.0%	0.0%	0.0%	0.0%
37	10	1.10%	76.0%	20.0%	0.0%	4.0%	0.0%
34	10	1.10%	70.0%	30.0%	0.0%	0.0%	0.0%

# LONG TERM EXPOSURE SITE STUDY

## ✓ VERY HIGHLY REACTIVE MIXES

BLOCK	AGG	Na <sub>2</sub> O <sub>e</sub>	CEM	FA	SLAG	SF	LITHIUM
52	6	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
16	6	0.66%	100.0%	0.0%	0.0%	0.0%	0.0%
53	6	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
17	6	0.88%	100.0%	0.0%	0.0%	0.0%	0.0%
64	6	0.88%	65.0%	0.0%	35.0%	0.0%	0.0%
68	6	0.88%	65.0%	0.0%	35.0%	0.0%	0.0%
65	6	0.88%	50.0%	0.0%	50.0%	0.0%	0.0%
69	6	0.88%	50.0%	0.0%	50.0%	0.0%	0.0%
62	6	0.88%	80.0%	20.0%	0.0%	0.0%	0.0%
66	6	0.88%	80.0%	20.0%	0.0%	0.0%	0.0%
63	6	0.88%	70.0%	30.0%	0.0%	0.0%	0.0%
67	6	0.88%	70.0%	30.0%	0.0%	0.0%	0.0%
54	6	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
18	6	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
15	UT1	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
48	UT2	1.10%	100.0%	0.0%	0.0%	0.0%	0.0%
61	6	1.10%	100.0%	0.0%	0.0%	0.0%	100.0%
25	6	1.10%	100.0%	0.0%	0.0%	0.0%	100.0%
24	6	1.10%	76.0%	0.0%	20.0%	4.0%	0.0%
57	6	1.10%	65.0%	0.0%	35.0%	0.0%	0.0%
21	6	1.10%	65.0%	0.0%	35.0%	0.0%	0.0%
58	6	1.10%	50.0%	0.0%	50.0%	0.0%	0.0%
22	6	1.10%	50.0%	0.0%	50.0%	0.0%	0.0%
59	6	1.10%	81.0%	15.0%	0.0%	4.0%	0.0%
23	6	1.10%	81.0%	15.0%	0.0%	4.0%	0.0%
55	6	1.10%	80.0%	20.0%	0.0%	0.0%	0.0%
19	6	1.10%	80.0%	20.0%	0.0%	0.0%	0.0%
60	6	1.10%	76.0%	20.0%	0.0%	4.0%	0.0%
56	6	1.10%	70.0%	30.0%	0.0%	0.0%	0.0%
20	6	1.10%	70.0%	30.0%	0.0%	0.0%	0.0%

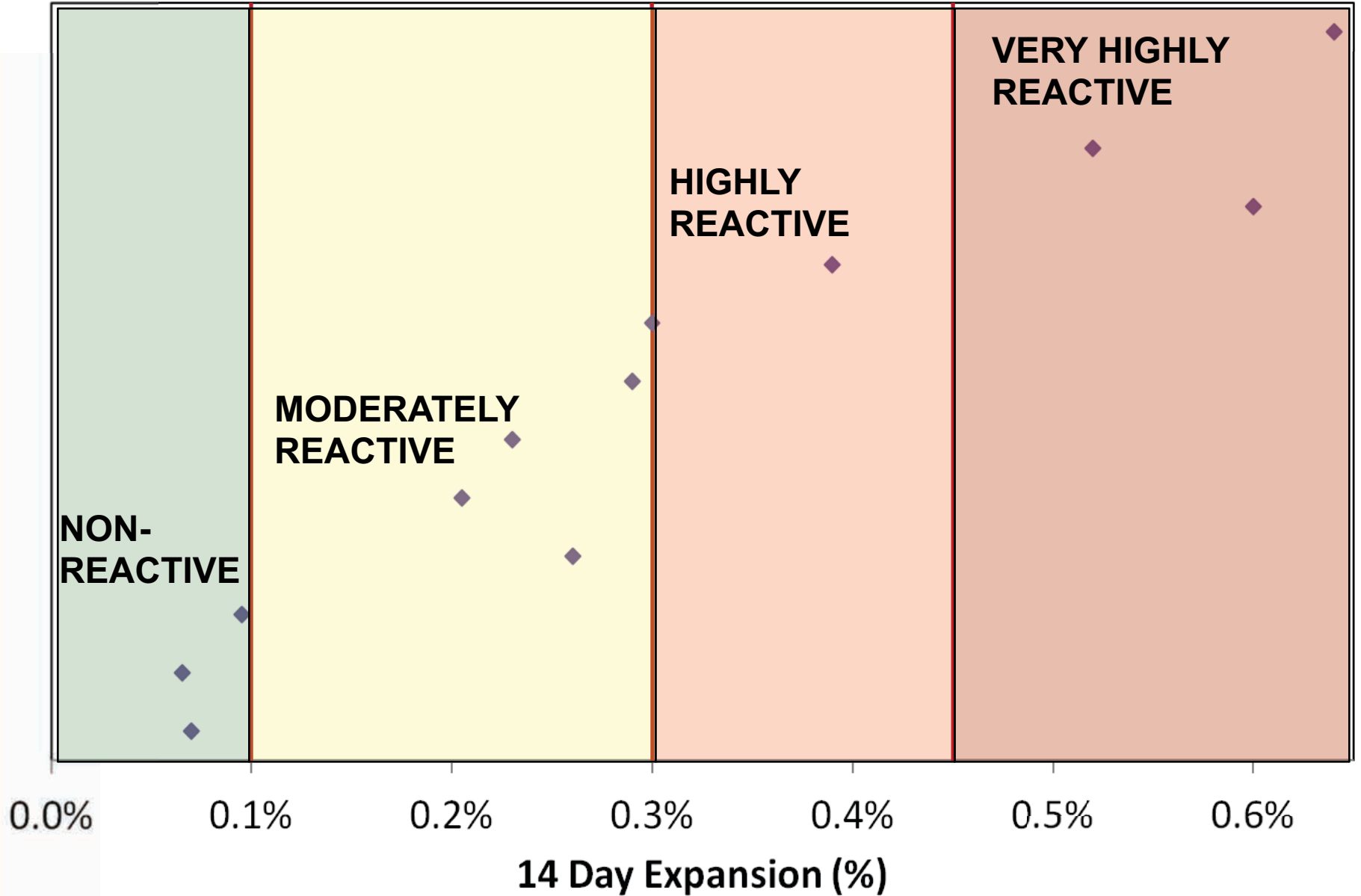
LONG TERM EXPOSURE SITE  
STUDY

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**LAB & FIELD  
RESULTS**

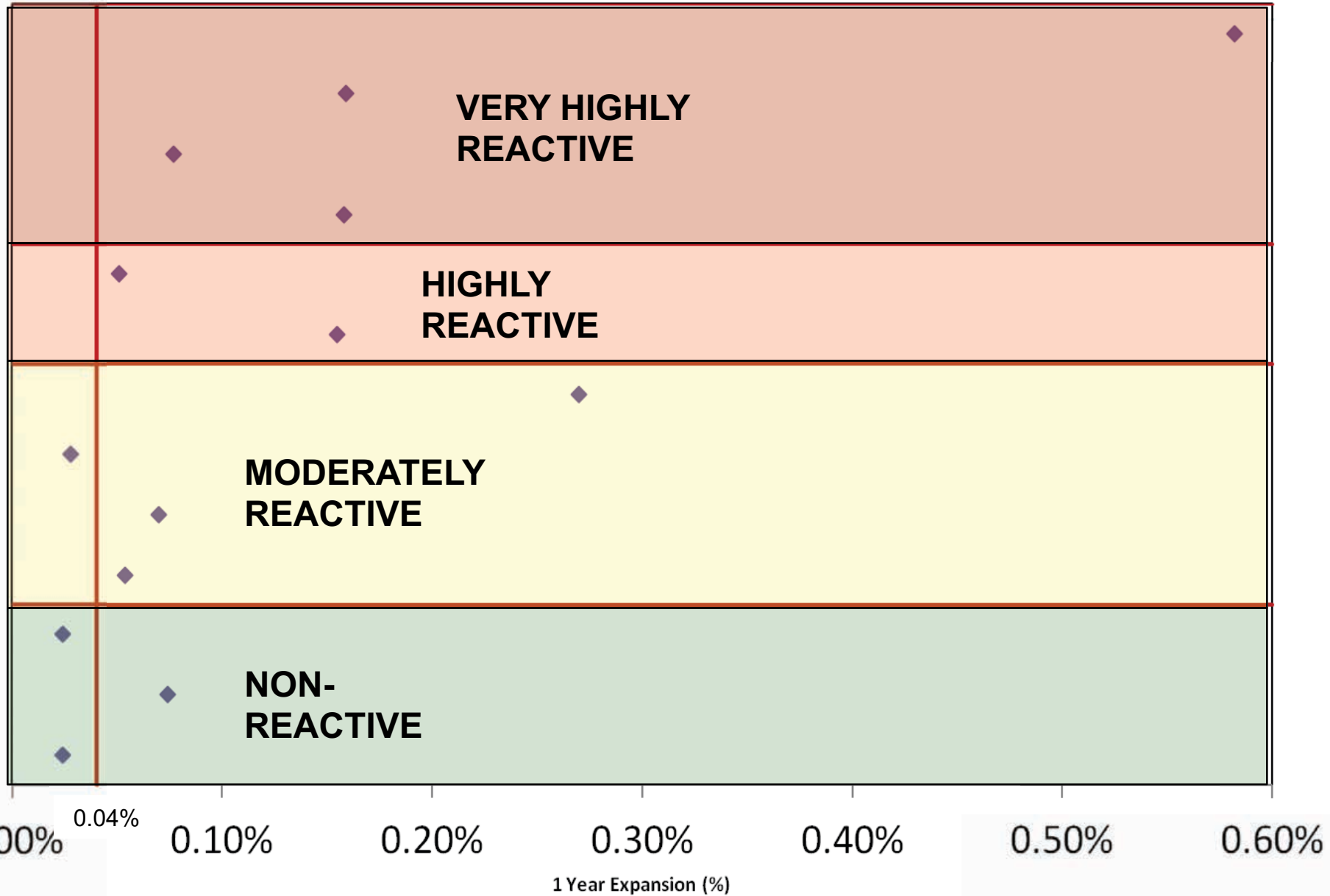


# AASHTO T 303 14 Day Expansion (%) for *100% Cement*

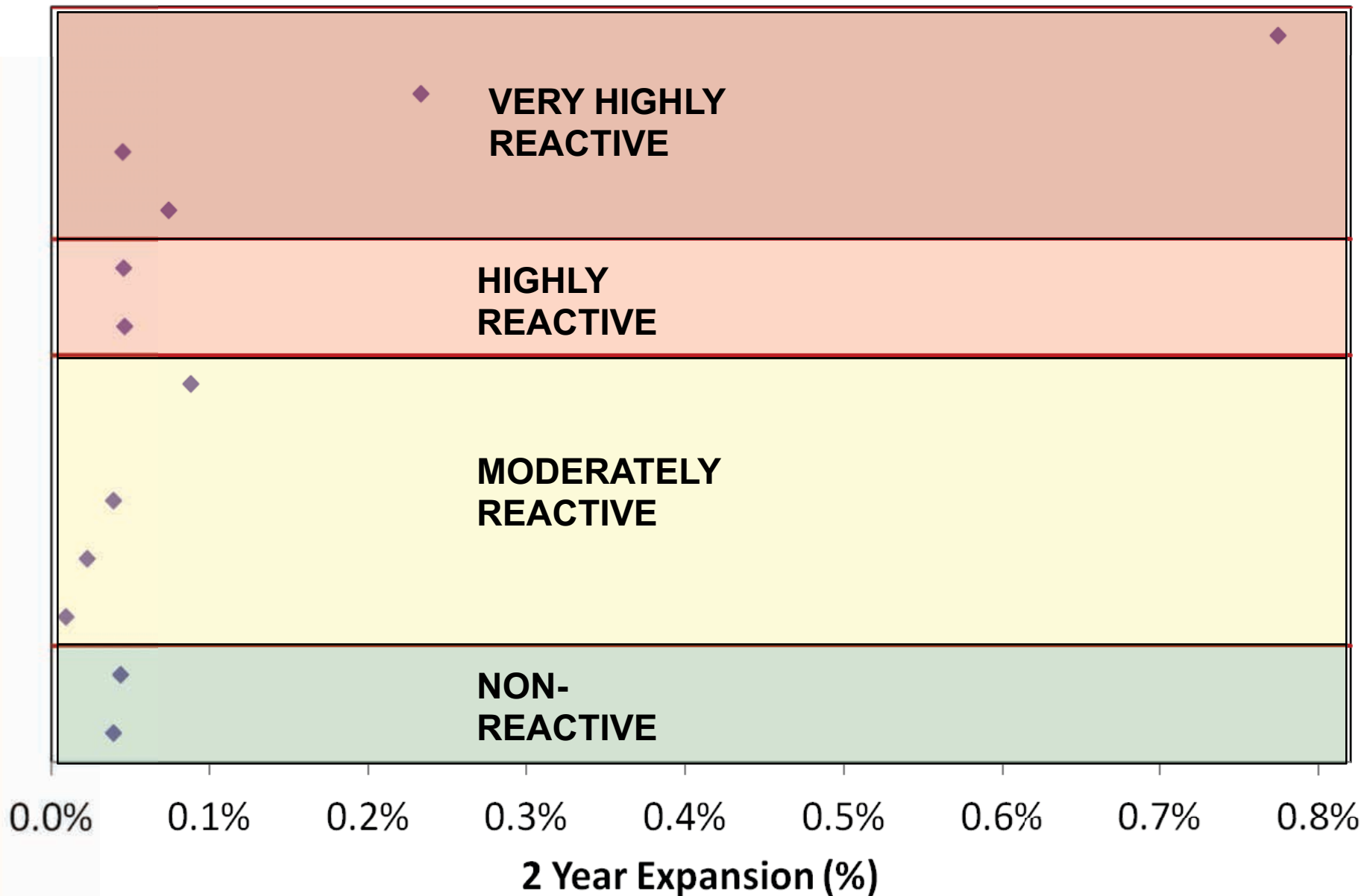


# ASTM C1293 1 Year Expansion (%) for 100% Cement

REACTIVITY LIMIT



Exposure Site 2 Year Expansion (%) for  
*1.11% Na<sub>2</sub>Oe; 100% Cement*





SAMPLE TYPE:

**VER**

RMS 907

BLOCK NO.

**48**

DATE RECEIVED:

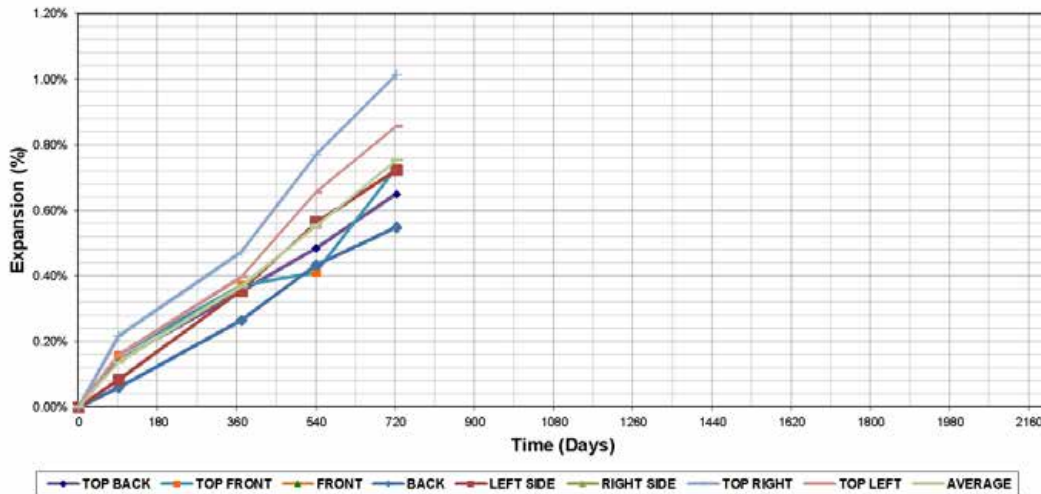
LAB NUMBER:

**CEMENT**
**ALKALINITY**
**FLY ASH**
**SLAG**
**SILICA**
**LITHIUM DOSE**
**100.0%**
**1.10%**
**0.0%**
**0.0%**
**0.0%**
**0.0%**
**MIX COMPONENTS**

Aggregate (Control):	Location:	Type:
Aggregate (Tested): UT2	Location: JOBE, TX	Type: COARSE
Cement:	Location:	Type:
Fly Ash:	Location:	Type:
Slag:	Location:	Type:
Silica Fume:	Location:	Type:
Lithium:	Location:	Type:

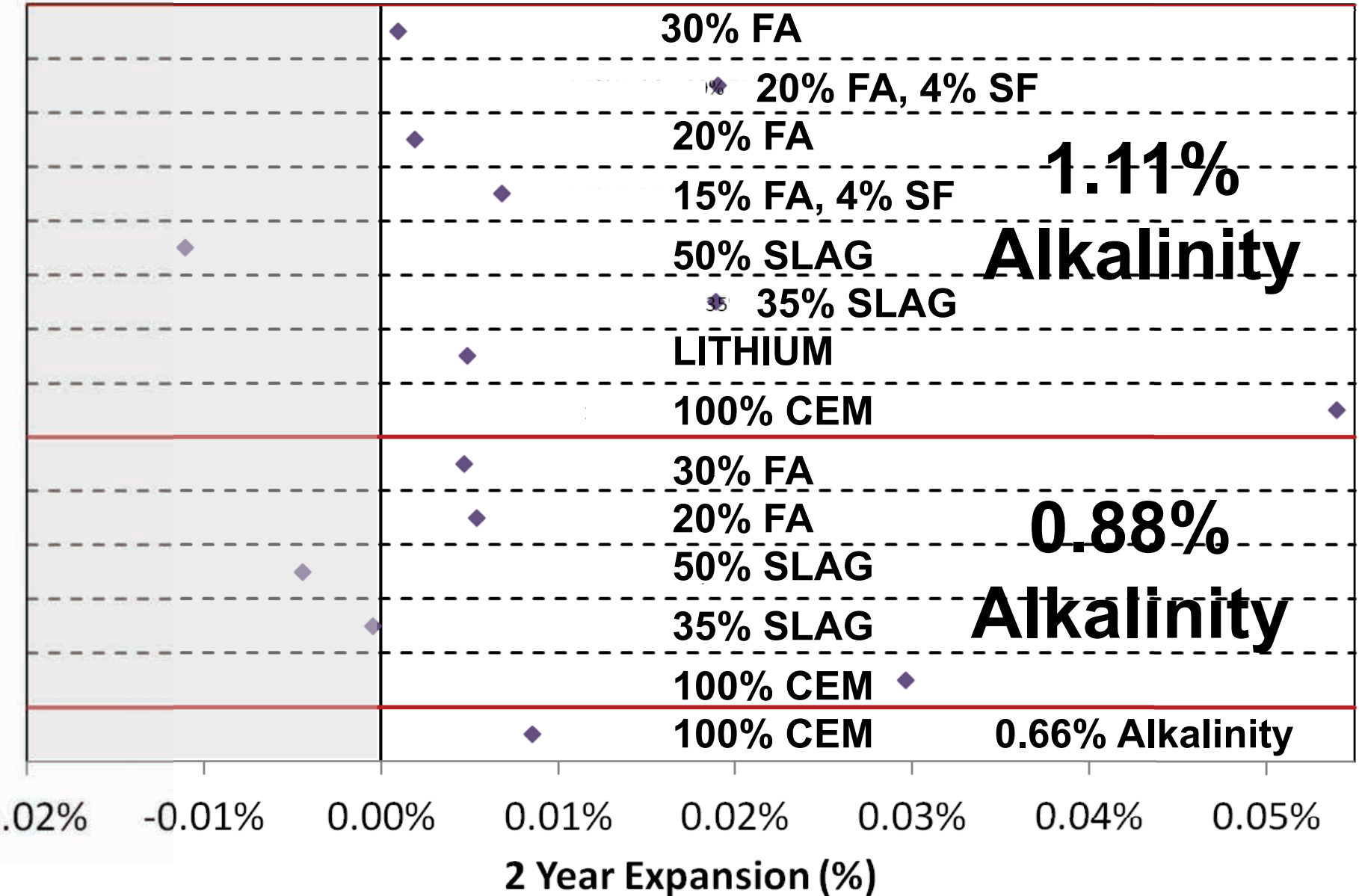
**AVERAGE EXPANSION (%)**

TIME (DAYS)	TOP BACK	TOP FRONT	FRONT	BACK	LEFT SIDE	RIGHT SIDE	TOP RIGHT	TOP LEFT	AVERAGE
0	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
91	0.1445%	0.1588%		0.0599%	0.0838%		0.2176%	0.1592%	0.1373%
371	0.3536%	0.3721%		0.2659%	0.3548%		0.4724%	0.3979%	0.3695%
540	0.4855%	0.4109%		0.4332%	0.5642%		0.7696%	0.6565%	0.5533%
723	0.6502%	0.7290%		0.5487%	0.7231%		1.0146%	0.8571%	0.7538%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%
	0.0000%	0.0000%		0.0000%	0.0000%		0.0000%	0.0000%	0.0000%

**EXPANSION (%) VS TIME (DAYS) PLOT**

**SIGNATURE**

Tested by:	Reviewed by:
Signature:	Signature:
Date:	Date:

Exposure Site 2 Year Expansion (%) for  
Aggregate 6 (Very Highly Reactive)



# CONCLUSION

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- ✓ Evaluate Exposure Site (10 – 20 years)
- ✓ Establish Trends
- ✓ Correlate Field Performance with Lab Tests
- ✓ Verify Aggregate Sources
- ✓ Prescribe Mitigation to eliminate ASR

# CONCLUSION

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✓ There is no Silver Bullet...





**END OF PRESENTATION**

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**QUESTIONS OR  
COMMENTS?**

