ASSESSMENT OF AGGREGATE REACTIVITY USING AN ULTRA-RAPID AUTOCLAVE TEST METHOD

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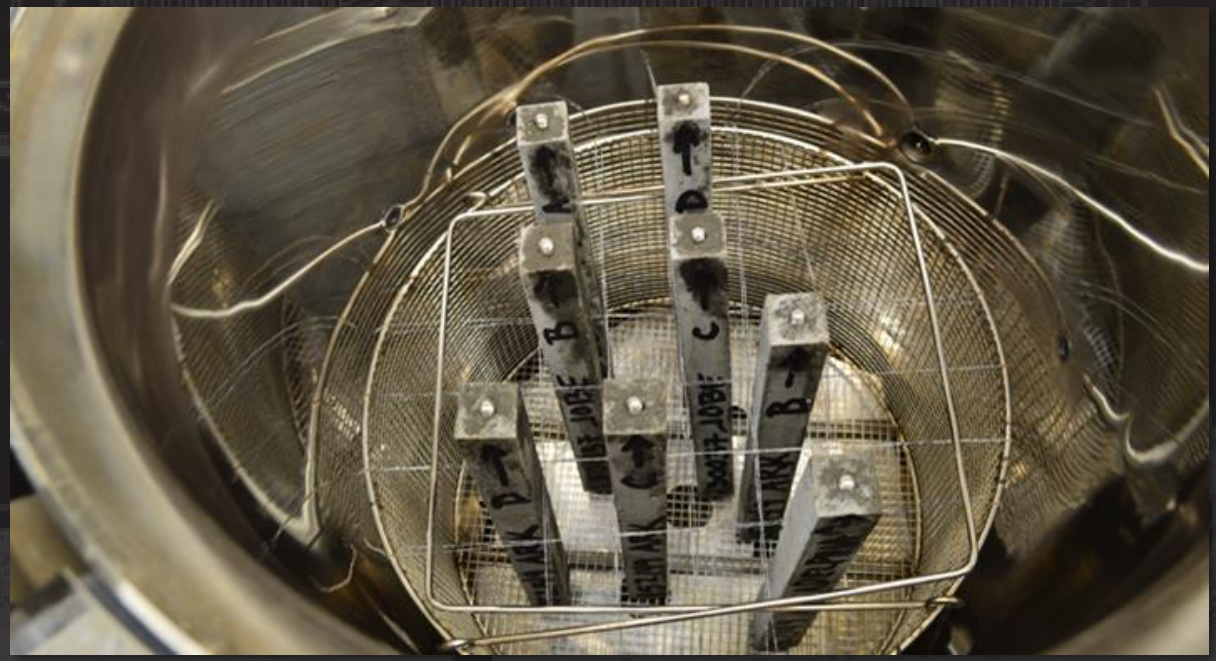

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MOTIVATION

Problem: Need rapid and reliable test methods for ASR potential of concrete aggregates

- ASTM C1293 concrete prism test (CPT)
  - 1 year to test using (portland) cement only
  - 2 years to test using preventive SCMs, e.g., coal ash
  - Not practical for construction projects or the US military
- ASTM C1260 / C1567 accelerated mortar bar tests (AMBT)
  - 14 days testing duration
  - Produce false positive and false negative results
  - Commonly used in construction projects due to rapidity

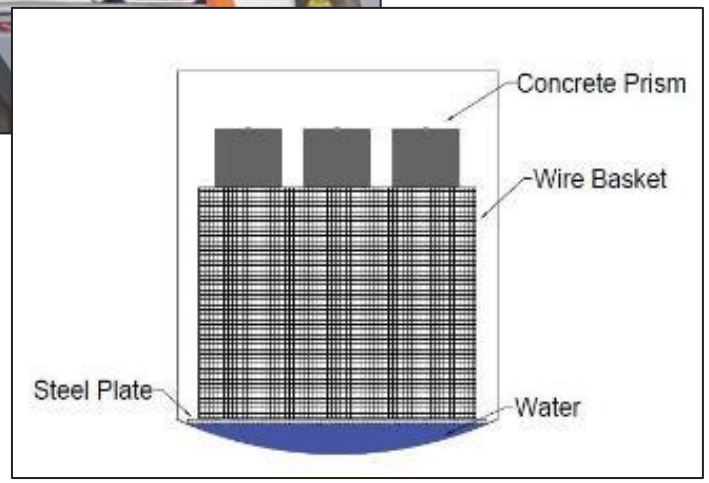
Overarching Goal: Validate autoclave test methods.

If accuracy ≥ that of ASTM C1260 and ASTM C1567, then specify autoclave test methods as alternatives.

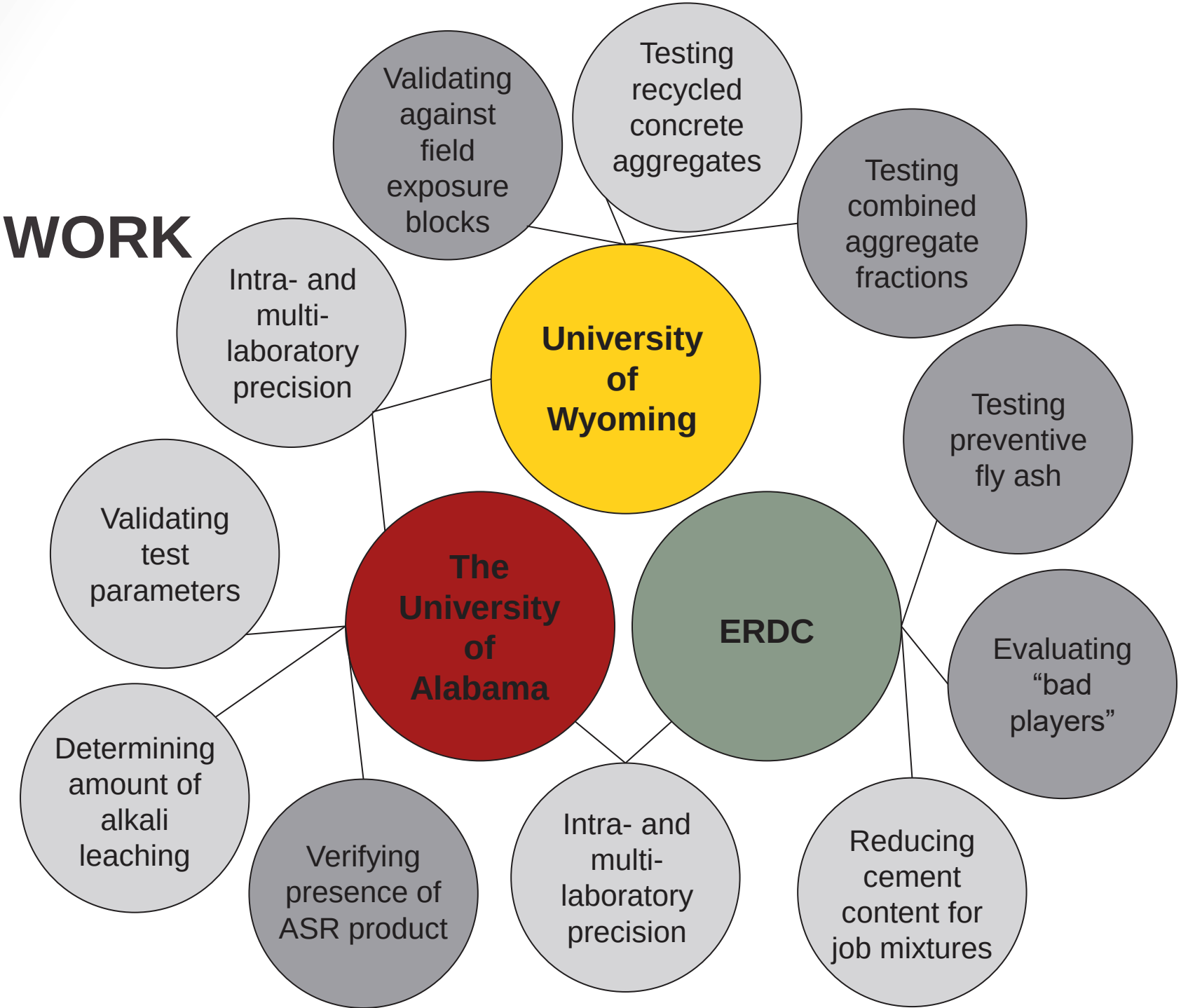
HISTORY OF AUTOCLAVE TEST METHODS

Test Parameter	Chinese Autoclave Method (1983)	GBRC (1987)	Nishibayashi et al. (1987)	Laval/ CANMET (1991)	Nishibayashi et al. (1996)	Giannini and Folliard (2013)
Duration (from mixing)	3 days	3 days	2 days	3 days	unknown	4 days
Duration of Conditioning	6 hours	2 hours	4 to 5 hours	5 hours	4 hours	24 hours
Specimen Type	Mortar	Mortar	Mortar	Mortar	Concrete	Concrete
Specimen Size, mm	10 x 10 x 40	40 x 40 x 160	40 x 40 x 160	25 x 25 x 285	75 x 75 x 400	75 x 75 x 285
w/cm	0.30	unknown	0.45	0.50	0.54	0.42
Na_2O_{eq}, by mass of cement	1.5%	2.5%	1.5%	3.5%	3.0%	3.0%
Temperature	150 °C	111 °C	128 °C	130 °C	133 °C	133 °C
Conditioning	In 10% KOH solution inside autoclave	In boiling water inside pressure vessel	Inside autoclave	Inside autoclave	Inside autoclave	Inside autoclave
Proposed Expansion Limit	-	-	-	0.15%	-	0.08%

AUTOCLAVING PROCESS

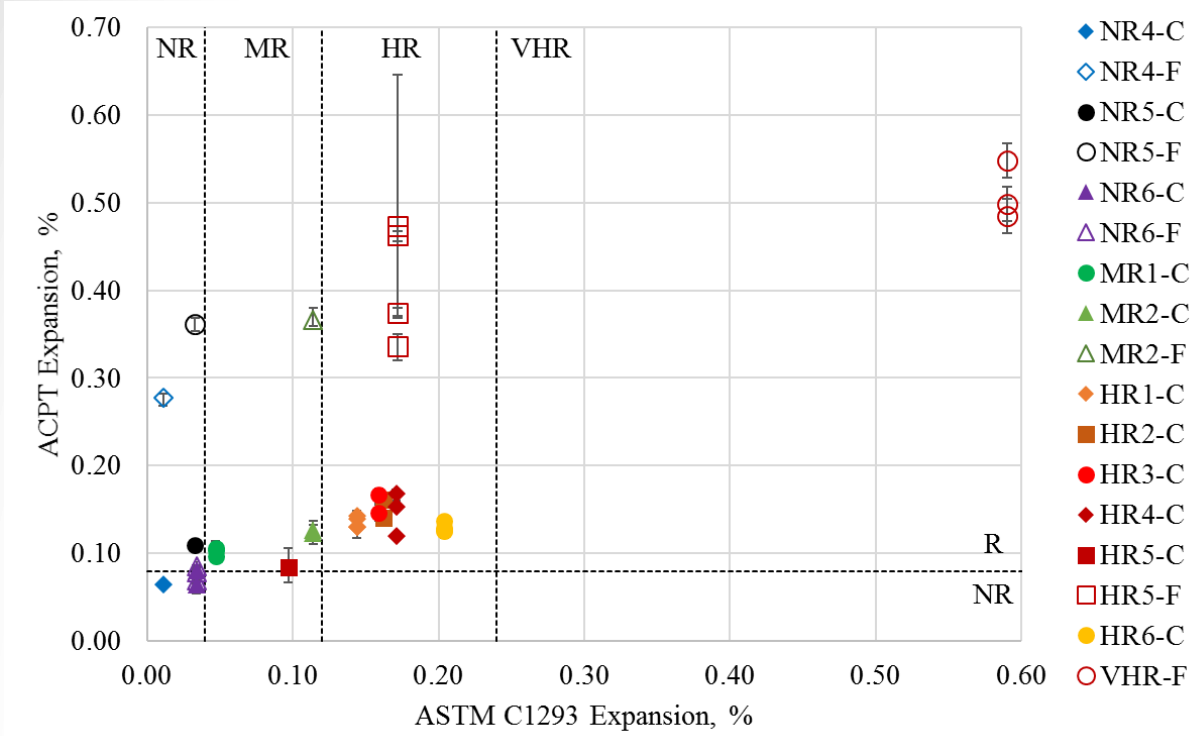


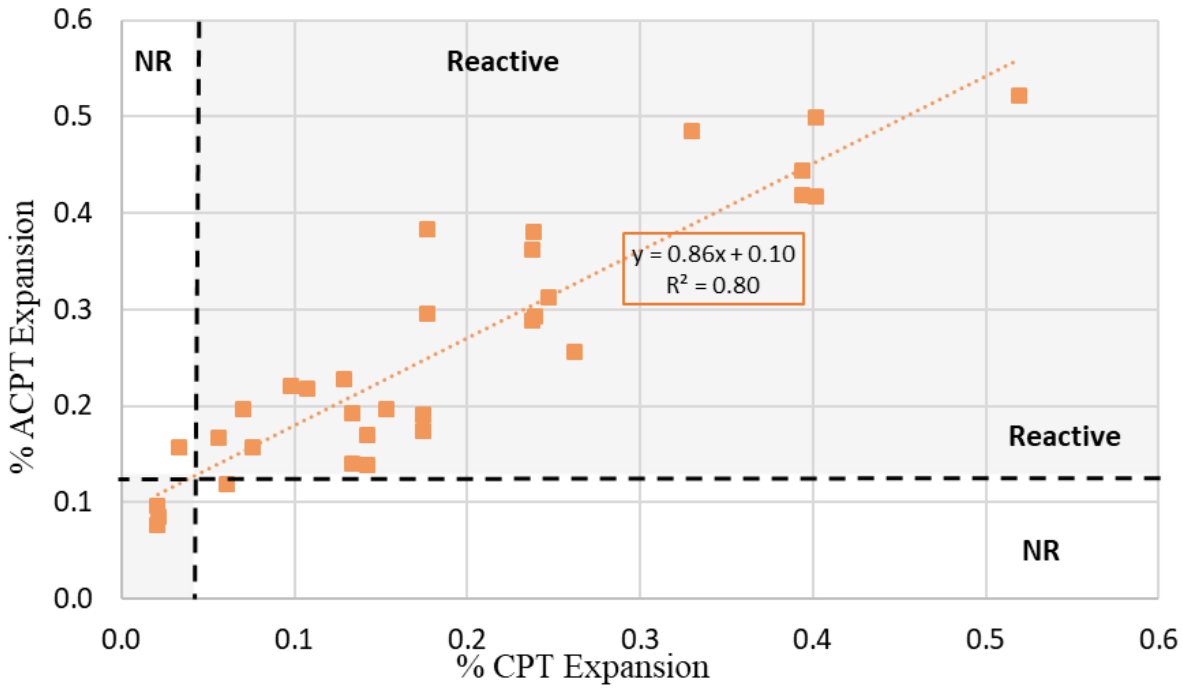
RECENT WORK


Validating against field exposure blocks
Testing recycled concrete aggregates
Testing combined aggregate fractions
Intra- and multi-laboratory precision
University of Wyoming
Testing preventive fly ash
Validating test parameters
The University of Alabama
ERDC
Evaluating “bad players”
Determining amount of alkali leaching
Verifying presence of ASR product
Intra- and multi-laboratory precision
Reducing cement content for job mixtures

AUTOCLAVED CONCRETE PRISMS VS. ASTM C1293

Overall Agreement: 85%

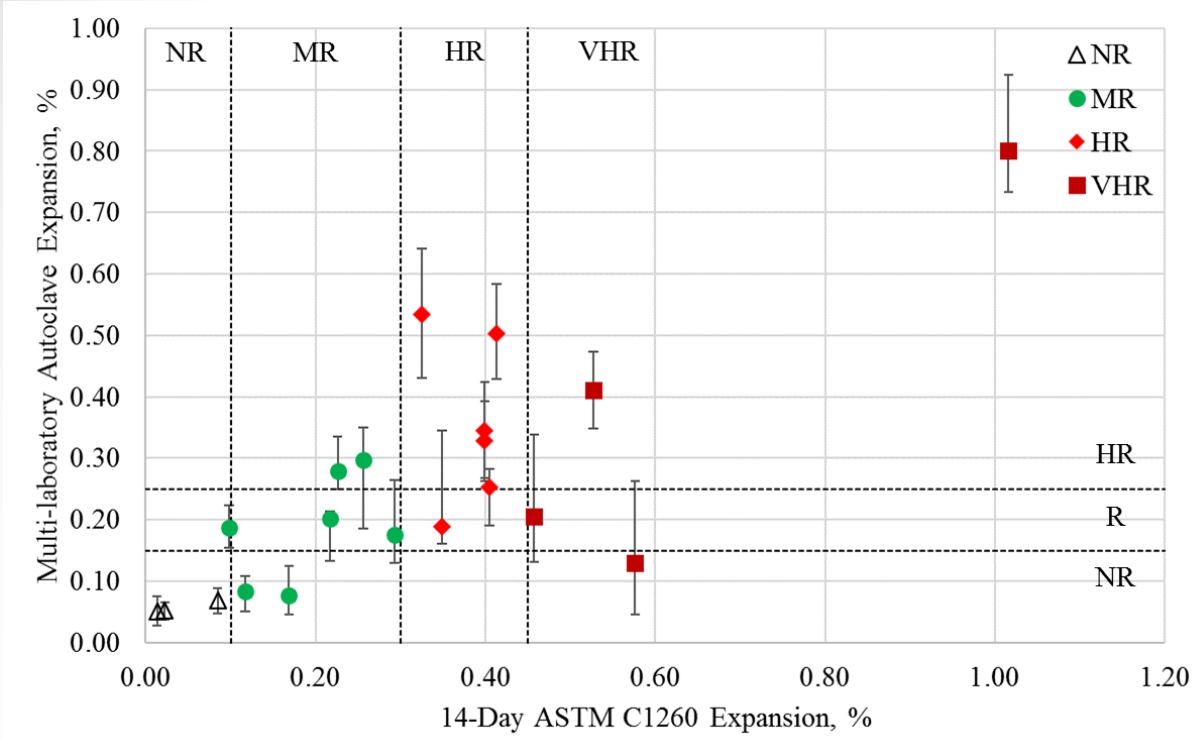




Coarse Aggregates: 93% Fine Aggregates: 69%

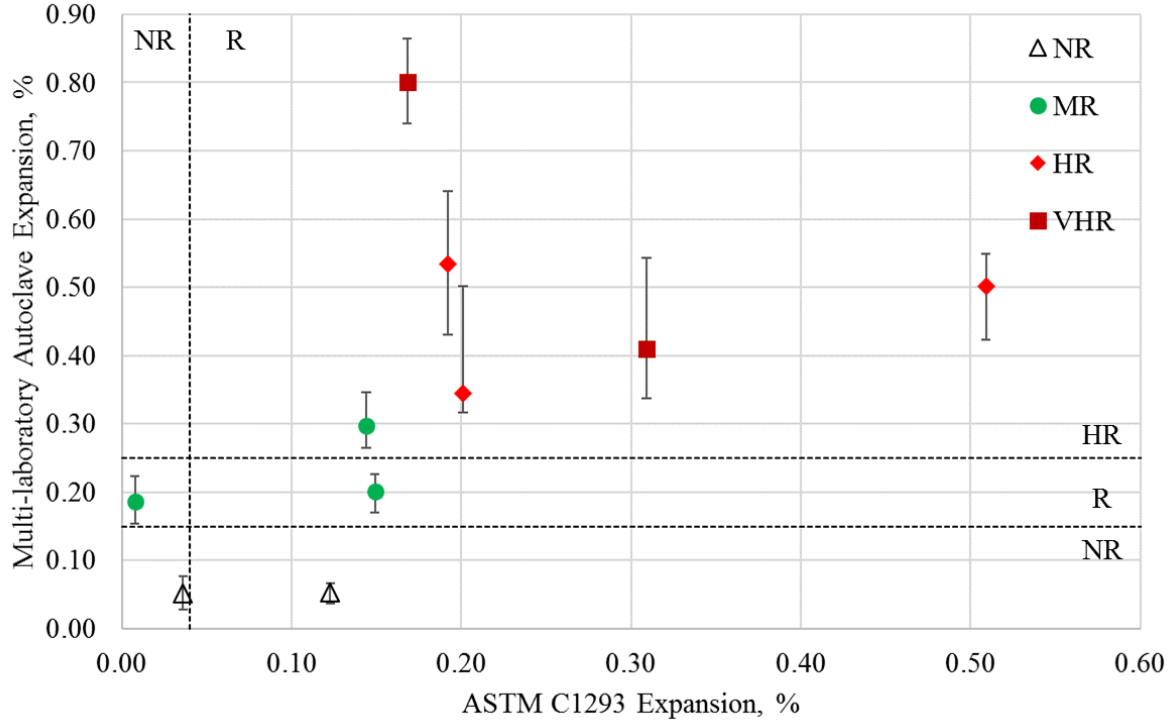
AUTOCLAVED MORTAR BARS (LAVAL/CANMET METHOD)

Compared to ASTM C1260



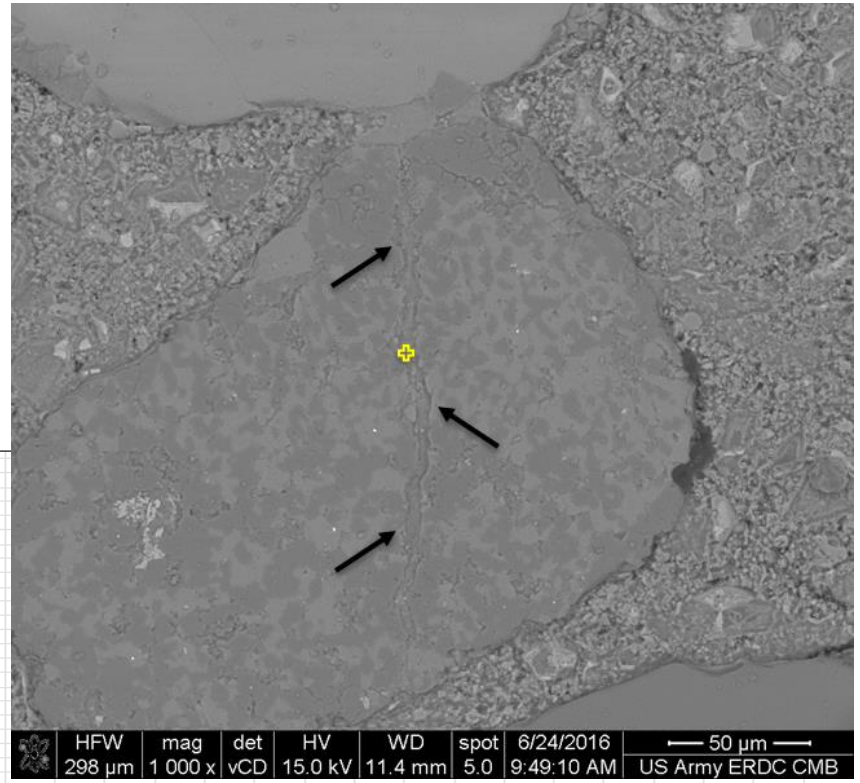
85% agreement for 20 aggregates

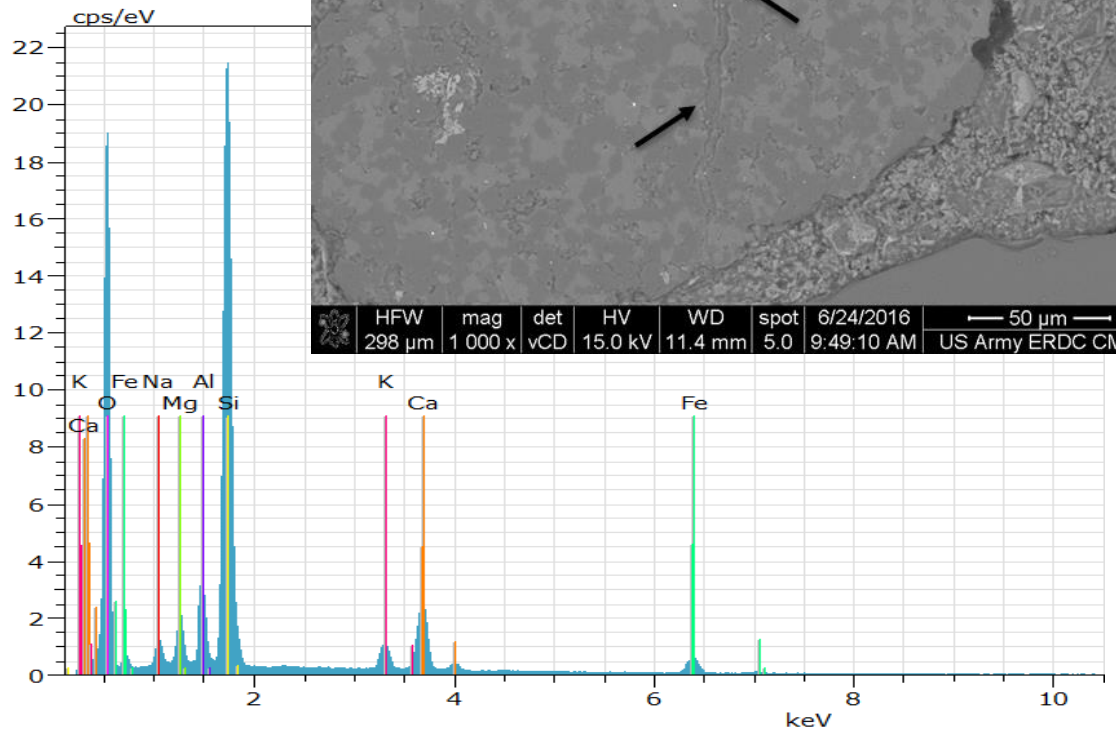
Compared to ASTM C1293

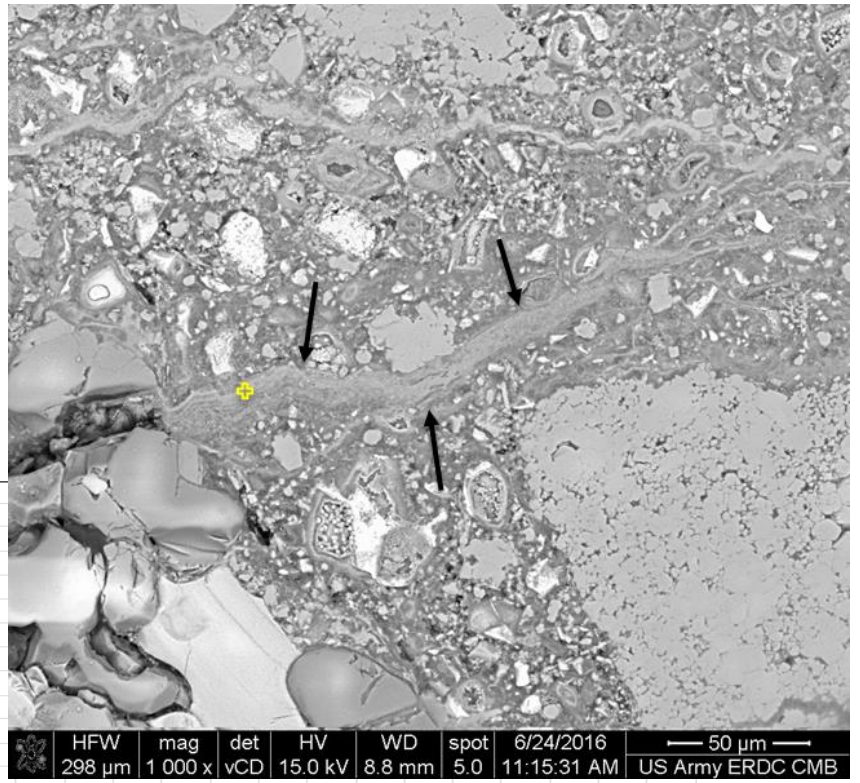


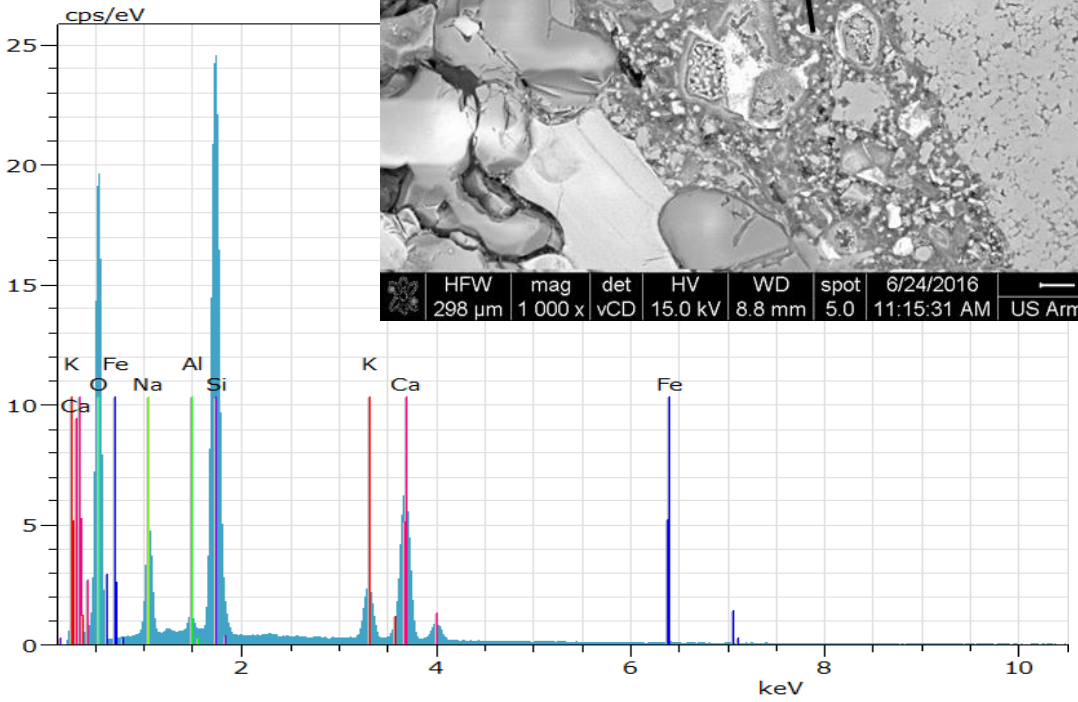
80% agreement for 10 aggregates

PRELIMINARY SEM-EDS INVESTIGATION



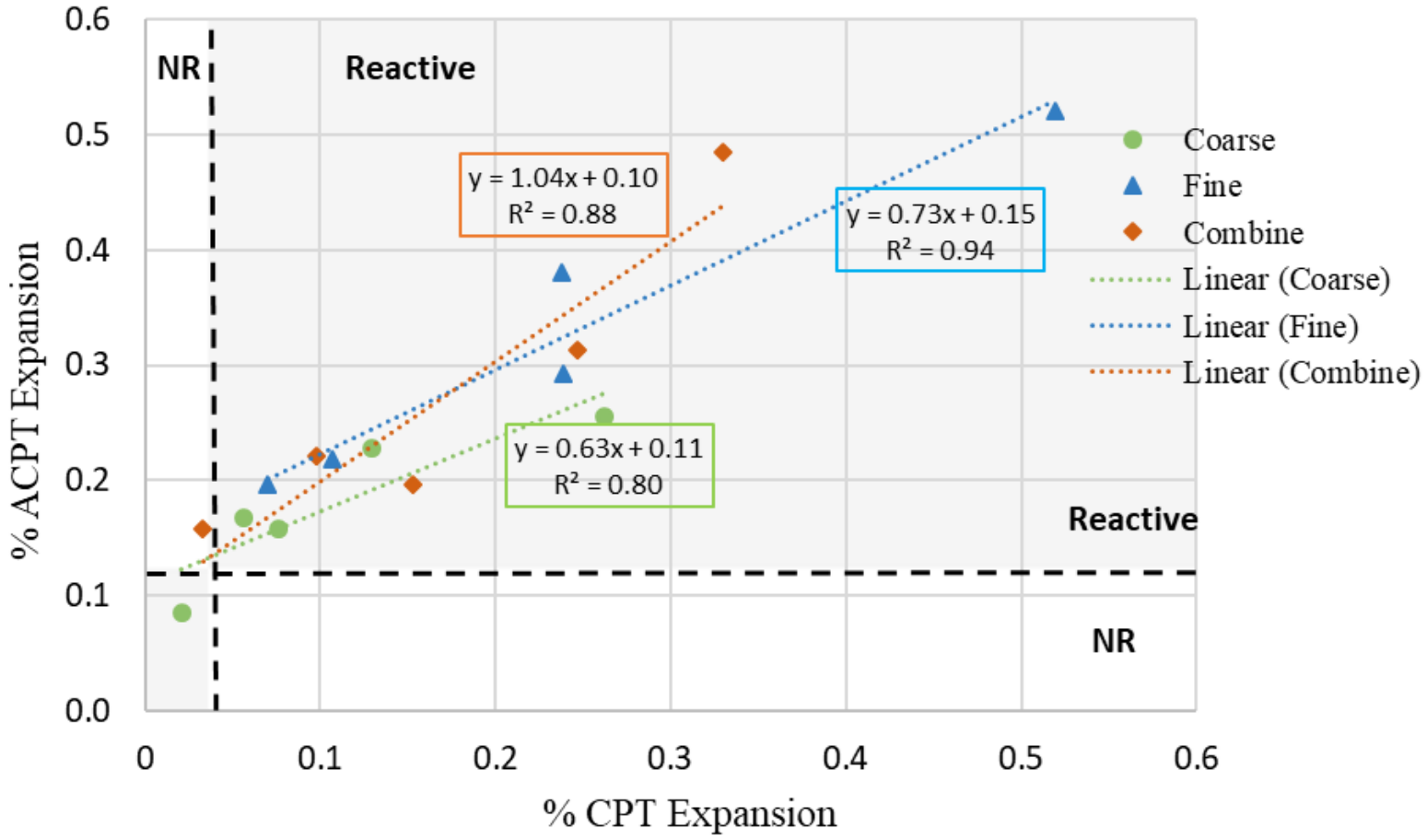






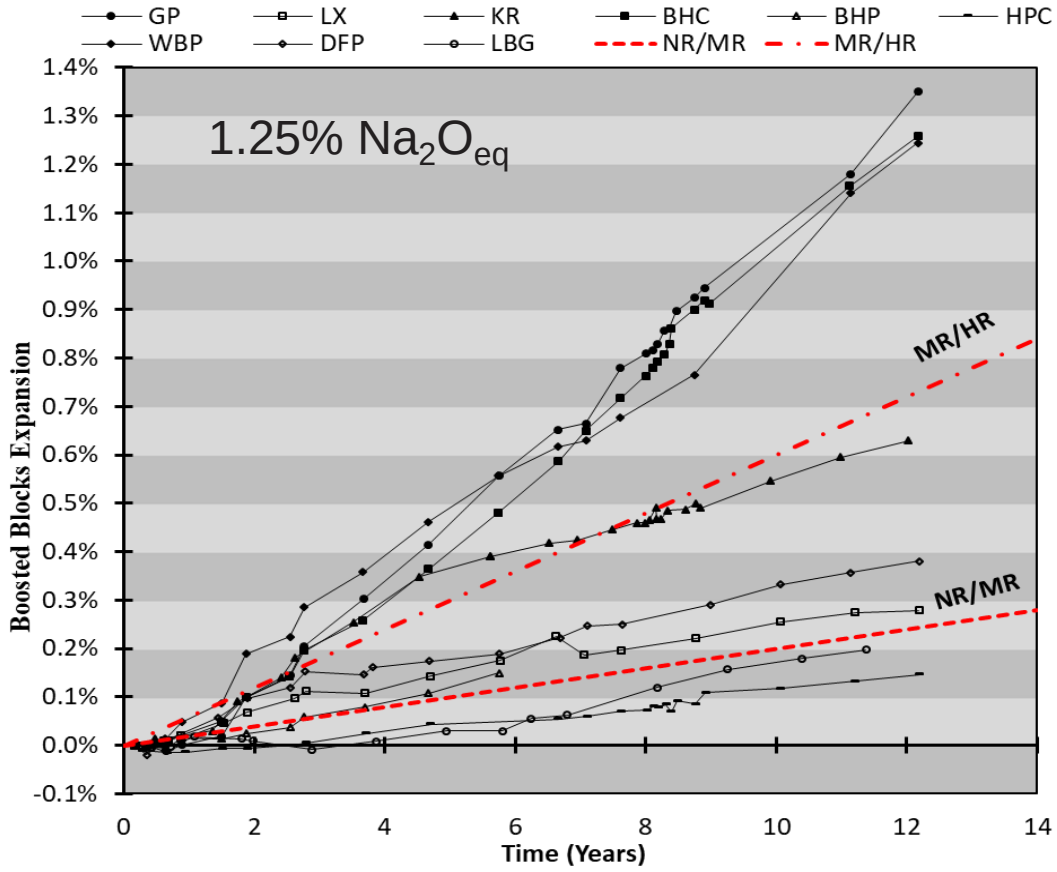
COMBINED AGGREGATE FRACTIONS

Compared to ASTM C1293



FIELD EXPOSURE BLOCKS

Aggregate Source	Reactivity Classification				
	Field Exposure Blocks		CPT	ACPT	
	Unboosted	Boosted		Coarse	Fine
BHP	NR	MR	NR	--	--
DFP	NR	MR	NR	--	--
BHC	NR	HR	NR	--	--
GP	HR	HR	MR	MR	VHR
HPC	NR	NR	NR	NR	MR
KR	HR	HR	HR	HR	VHR
LBG	NR	NR	HR	MR	HR
LX	NR	MR	MR	--	--
WOR	HR	HR	MR	MR	VHR



RECENT ERDC WORK - AGGREGATES

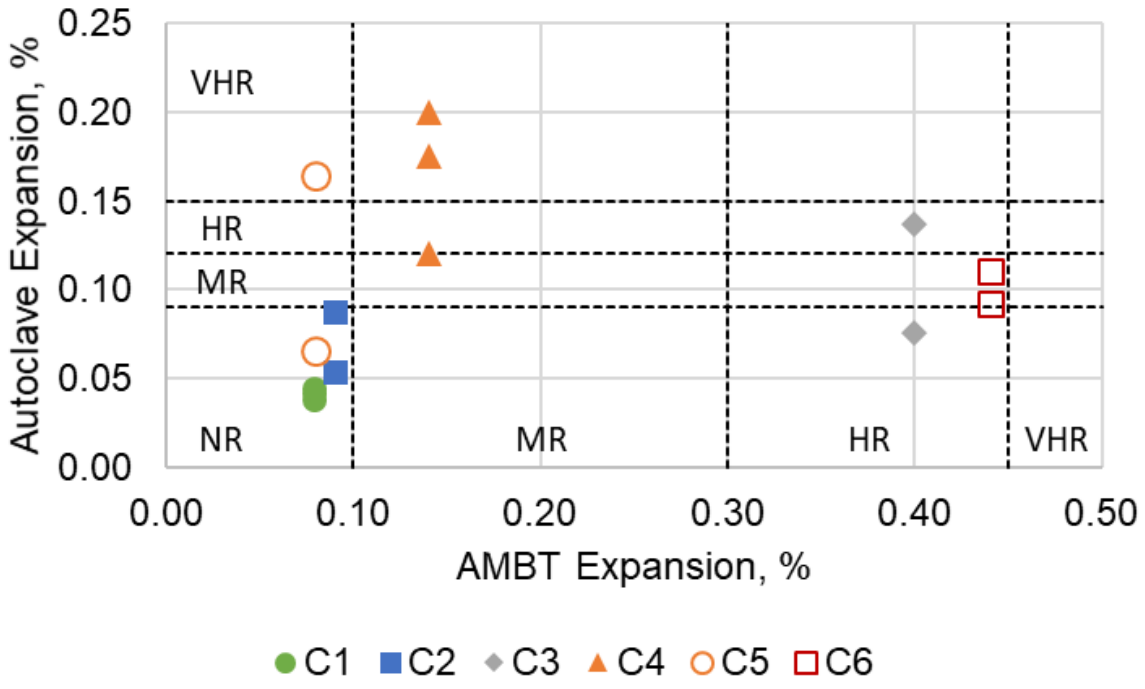
Aggregate ID	Mineralogy	Source Location	Reactivity Classification*		
			AMBT	CPT	Field Exposure Block
C1	Limestone	Georgia	NR	NR	-
C2	Mixed quartz, chert	Arkansas	NR	MR	VHR
C3	Rhyolite, mixed quartz	Virginia	HR	HR	VHR
C4	Quartzite	South Dakota	MR	HR	VHR
C5	Grandodiortie and metadacite	Maryland	NR	MR	VHR
C6	Greywacke	Pennsylvania	HR	HR	VHR

* Based on ASTM C1778 guidance
NR – non-reactive
MR – moderately reactive
HR – highly reactive
VHR – very highly reactive

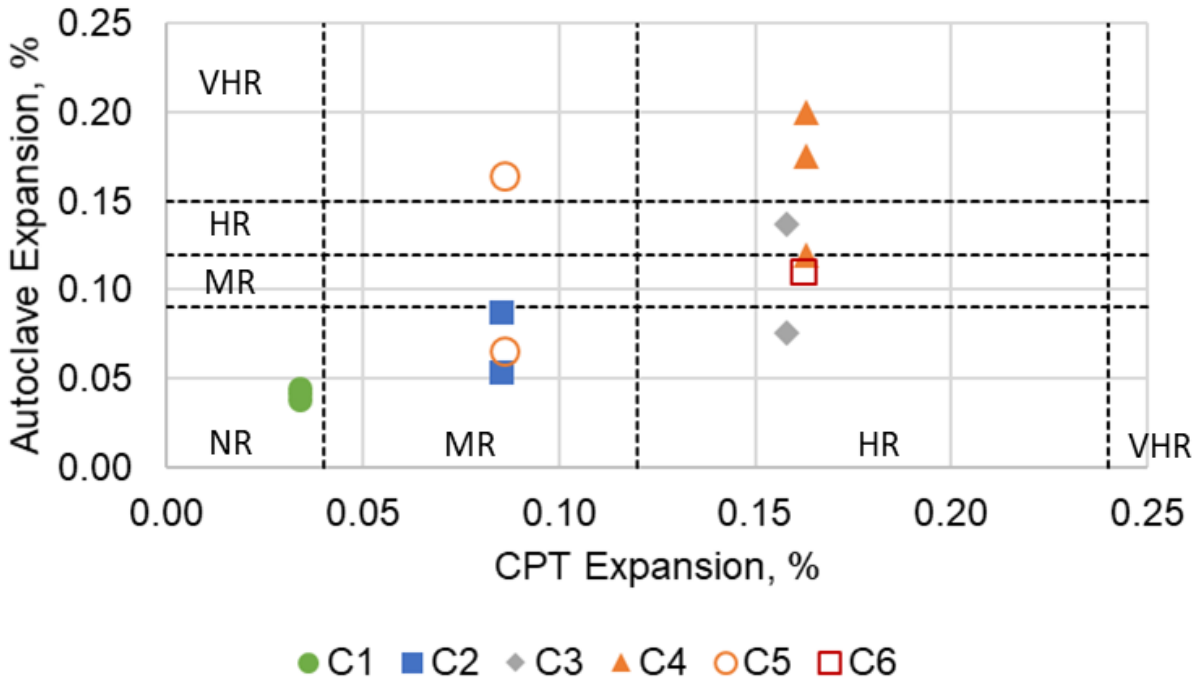
Reactivity Classification	Ranges of Expansion, %			
	ASTM C1260 (AMBT)	ASTM C1293 (CPT)	Autoclaved Concrete Prisms	Autoclaved Mortar Bars
NR	exp. < 0.10	exp. < 0.04	exp. < 0.09	exp. < 0.15
MR	0.10 ≤ exp. < 30	0.04 ≤ exp. < 12	0.09 ≤ exp. < 12	0.15 ≤ exp. < 25
HR	0.30 ≤ exp. < 0.45	0.12 ≤ exp. < 0.24	0.12 ≤ exp. < 0.15	0.25 ≤ exp. < 0.40
VHR	0.45 ≤ exp.	0.24 ≤ exp.	0.15 ≤ exp.	0.40 ≤ exp.

RECENT ERDC WORK - RESULTS

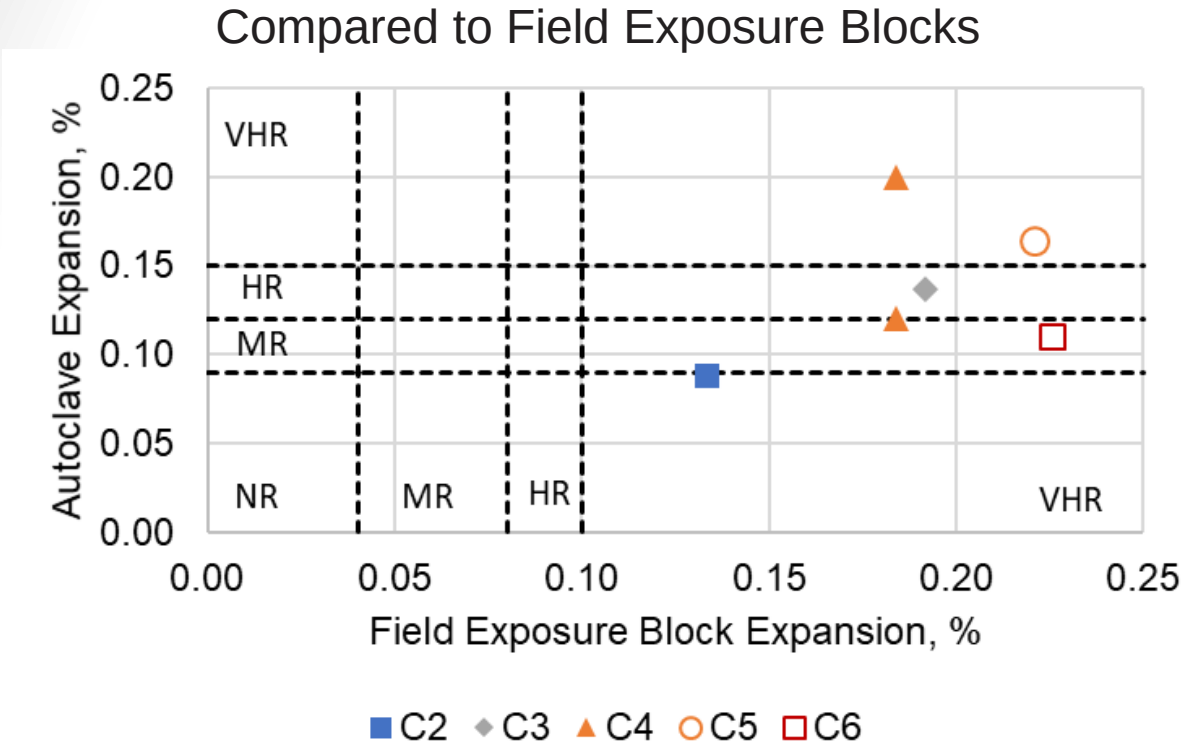
Compared to ASTM C1260

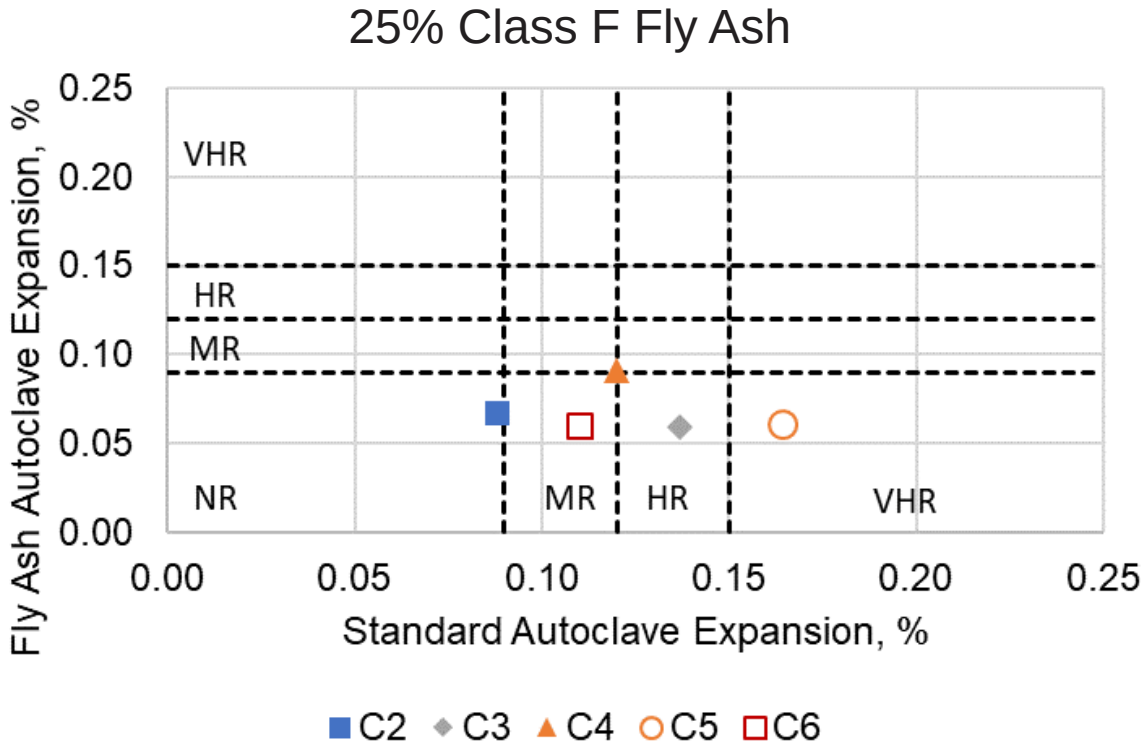


Compared to ASTM C1293



RECENT ERDC WORK - RESULTS





CONCLUSIONS AND FUTURE WORK

Conclusions

- Require two different autoclave methods for coarse and fine fractions
- Autoclave test methods induce ASR
- Accuracy of autoclave methods appears to be as good as ASTM C1260
- Multi-laboratory precision for Laval/CANMET method comparable to both ASTM C1260 and ASTM C1293
- Class F fly ash produced reduced expansions

Future Work

Goal for the US Air Force: Specify autoclave test methods as alternatives to ASTM C1260 and ASTM C1567

- Resolve discrepancies with repeat test results
- Continue to investigate ASR preventive measures such as slag cement and silica fume
- Carry out more petrographic investigations
- Compare results of slowly/moderately reactive aggregates to behavior of field exposure blocks

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