

MCO Test Results and Analysis

- Heat of Hydration and Setting Time

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Outline

- Chemical analysis (XRF)
- Setting time test results
- Calorimeter test results

XRF Test Results

- Chemical Composition of Cement

	Type	Source	C ₃ S	C ₂ S	C ₃ A	C ₄ AF
MO	I	Continenta	59.99	12.84	9.56	7.13
NC	I	Roanoke	62.06	10.71	6.83	9.71
WI	I	Cemex	51.71	17.59	7.21	9.25
MI	I	ST. Marys	57.56	11.83	10.23	6.76
TX	I/II	TXI	60.75	11.02	5.16	11.06
KS	I/II	Lafarge	53.61	18.61	7.54	9.89

Red: Type I;

Blue: Type I/II;

Pink: Type I(SM)

XRF Test Results

- Oxide Compositions of Cement

	CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	Alkalies	SO ₃	MgO
MO	63.87	20.27	5.10	2.34	0.09	0.13	0.18	2.93	2.85
NC	63.34	20.07	4.61	3.19	0.18	0.87	0.78	2.71	2.87
WI	61.22	19.74	4.66	3.04	0.17	1.61	1.27	4.15	3.67
MI	62.04	19.27	5.28	2.22	0.20	1.04	0.92	3.48	4.06
TX	62.59	19.83	4.27	3.63	0.18	0.62	0.61	3.32	1.38
KS	62.97	20.60	4.92	3.25	0.22	0.46	0.54	2.97	1.64
IA*	57.77	23.57	5.47	2.68	0.15	0.63	0.58	2.76	4.62

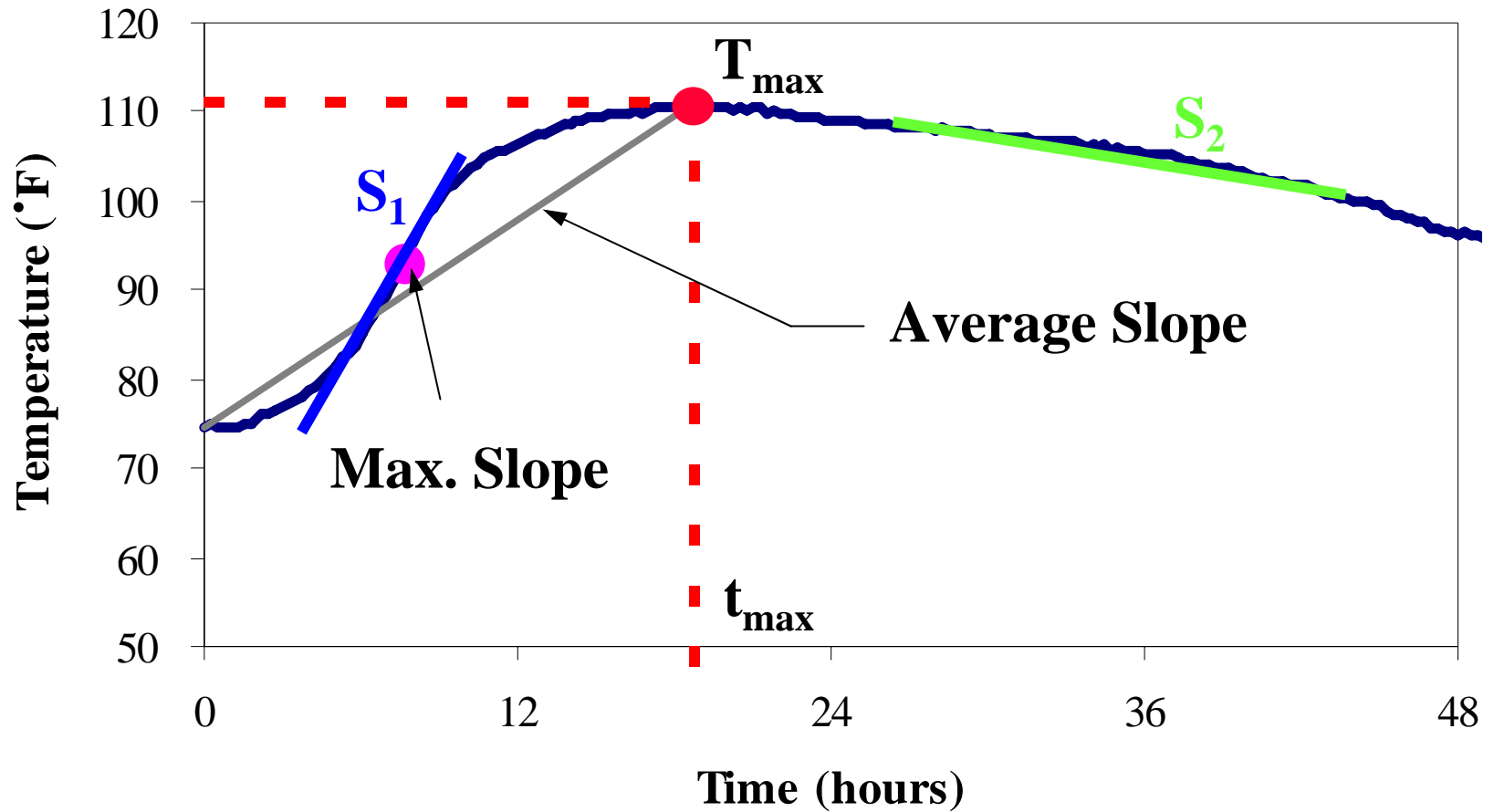
XRF Test Results

- Oxide Compositions of Fly Ash

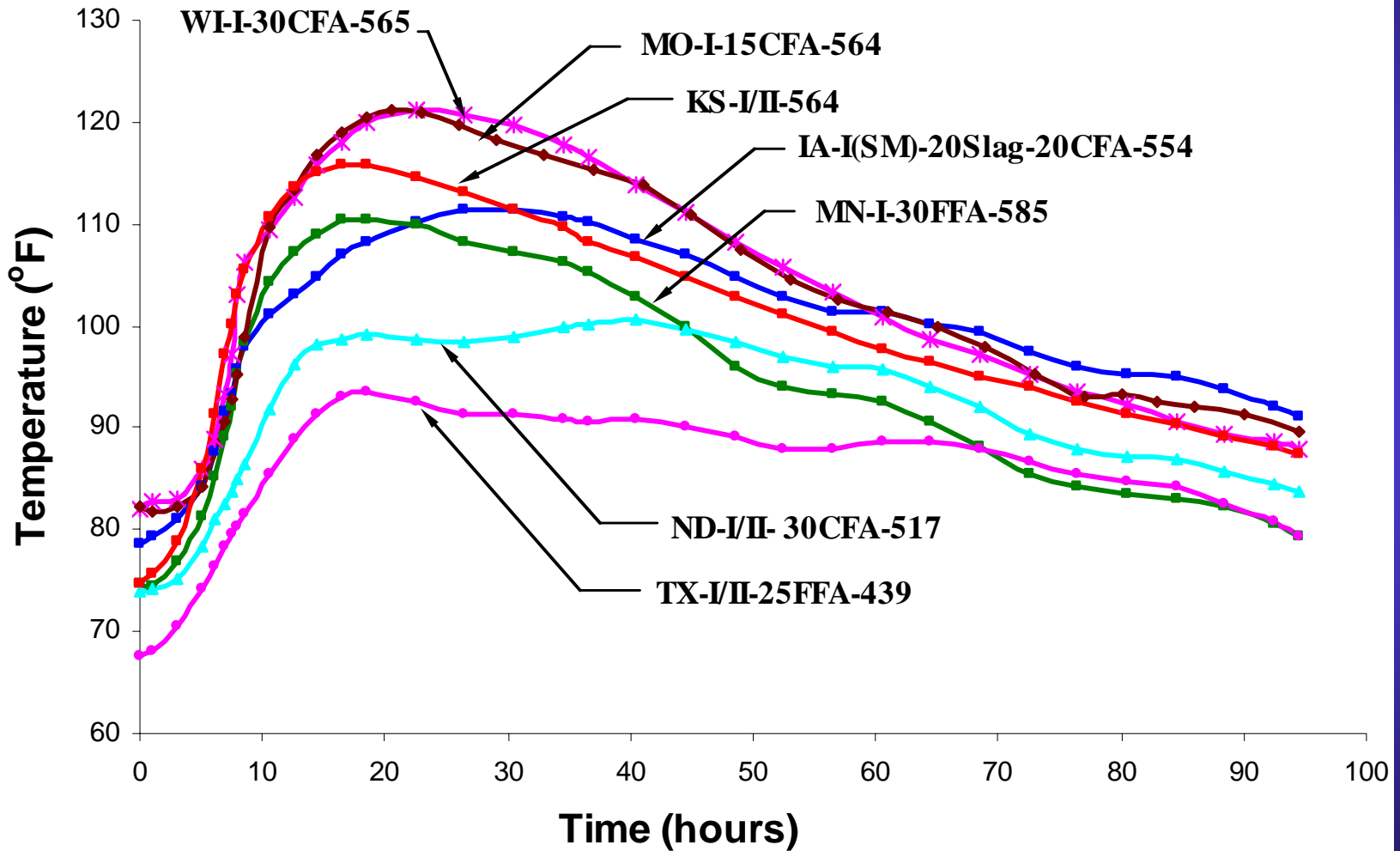
State	LOI	CaO	Al ₂ O ₃	SiO ₂	Fe ₂ O ₃	SO ₃	Na ₂ O	K ₂ O	Alkalies	MgO	SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃
MO	0.46	24.17	19.07	35.65	6.06	2.13	1.80	0.42	2.09	5.83	60.78
IA	0.48	27.87	18.26	31.32	5.57	2.99	2.91	0.33	3.13	6.55	55.16
WI	0.21	27.75	18.30	33.51	6.37	2.88	1.90	0.29	2.10	4.38	58.17
TX	0.32	13.27	19.96	50.73	7.18	0.88	0.56	0.95	1.21	2.65	77.87
NC	2.30	0.83	28.73	56.11	5.76	0.01	0.25	2.34	1.86	0.81	72.48

Brown: Class C fly ash; Green: Class F fly ash

Calorimeter Test Results



Calorimeter Test Results



Calorimeter Test Results

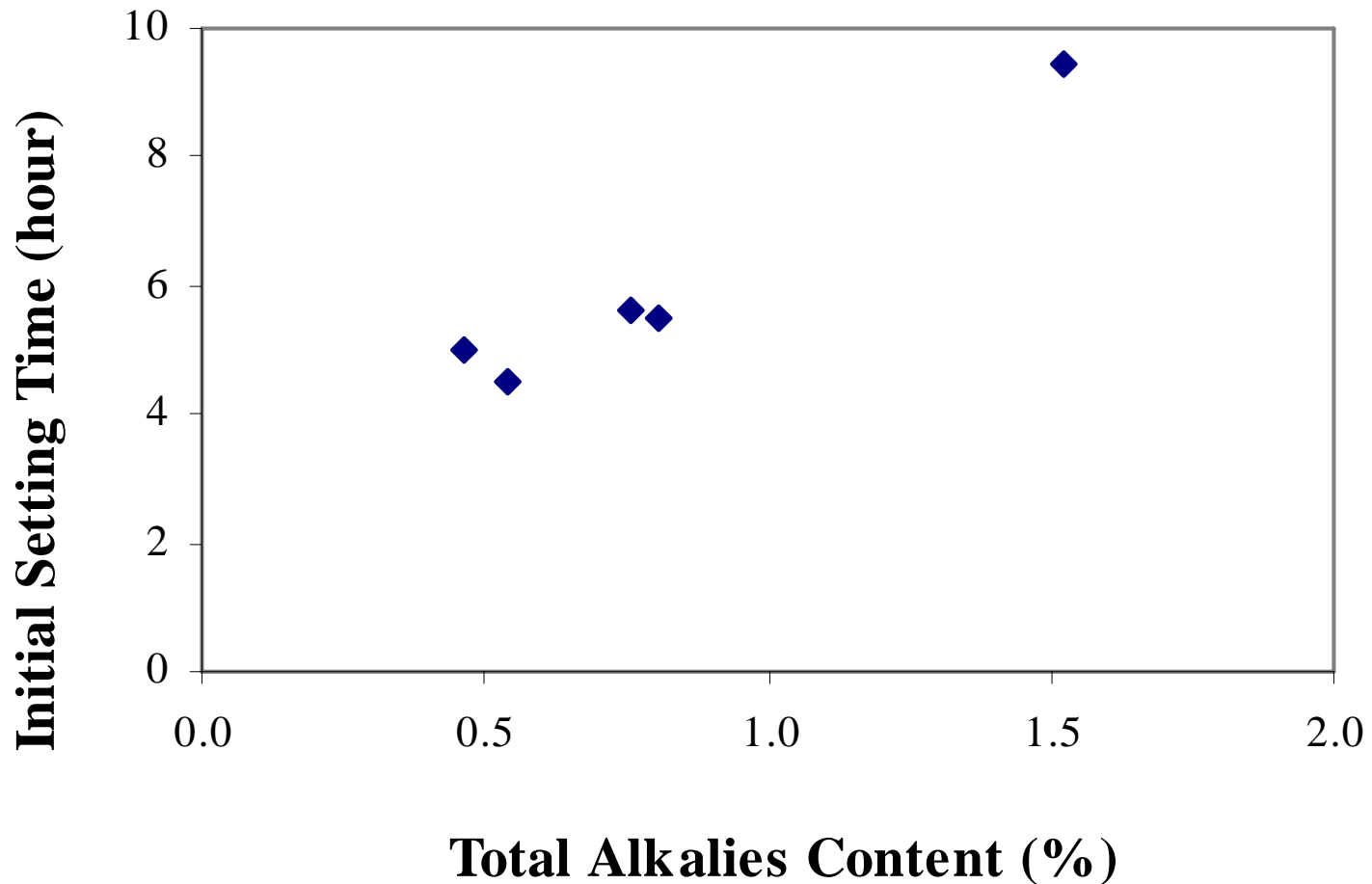
	Max Temp	Time for Max Temp	Average Slope	Max Slope	S₁	S₂
	(°F)	(hour)	(°F/hour)	(°F/hour)	(°F/hour)	(°F/hour)
KS	116.06	17.75	2.33	6.48	4.66	0.35
MO	121.30	21.00	1.85	8.46	4.02	0.44
ND	99.14	17.75	1.42	4.32	2.38	0.33
WI	121.10	20.75	1.88	12.24	4.36	0.59
TX	93.92	19.75	1.33	2.88	2.02	0.18
MN	110.84	18.75	1.93	6.48	4.37	0.40
IA	111.38	26.50	1.24	5.67	3.91	0.30

Red: cement; Blue: cement with type C fly ash; Pink: cement with type F fly ash; Brown: cement with slag and fly ash

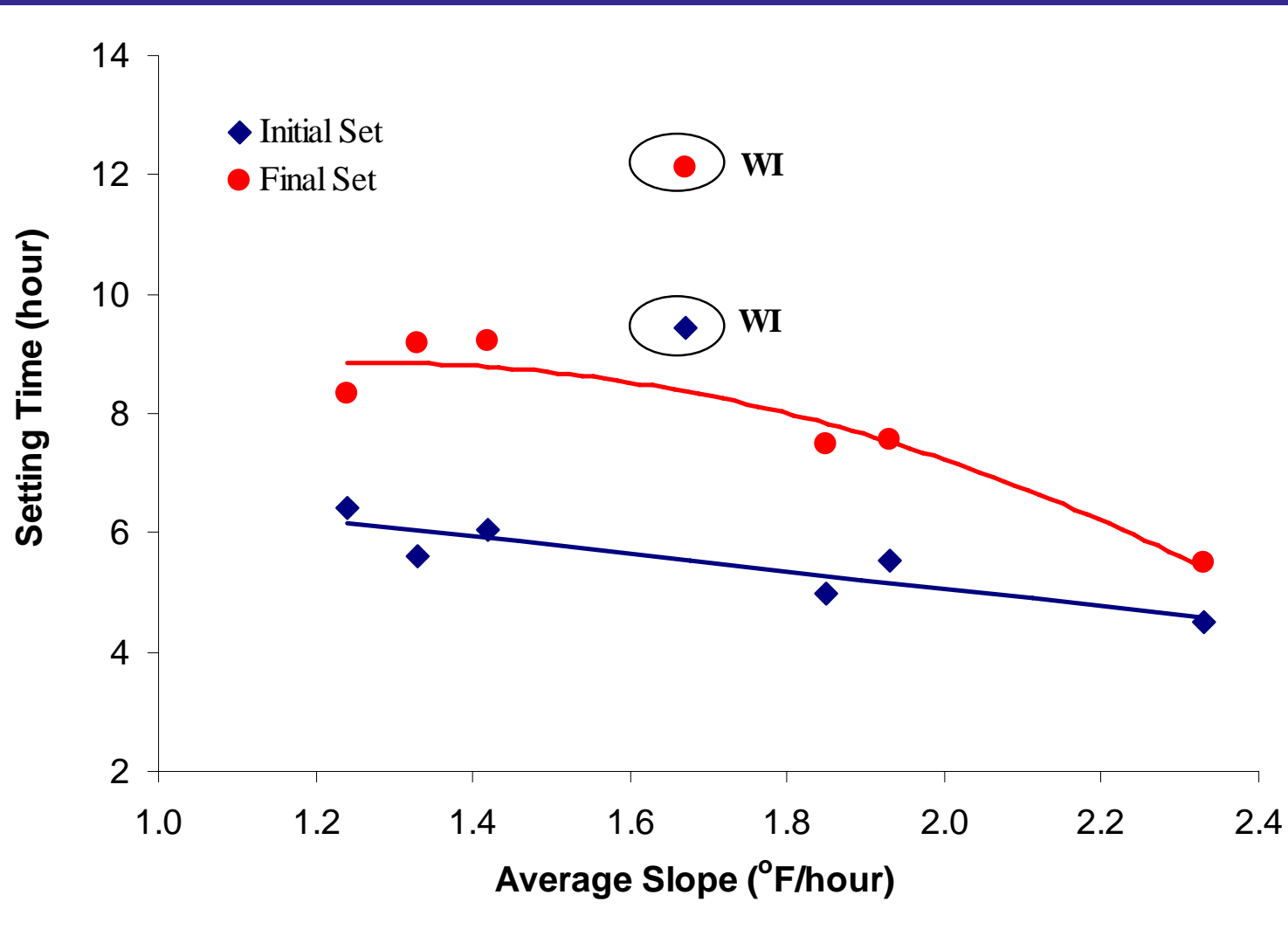
Setting Time Results

	Initial Set	Final Set	Initial Temp
	(hour)	(hour)	(°F)
KS	4.50	5.50	83.4
MO	4.99	7.47	
ND	6.05	9.22	75.9
WI	9.45	12.13	61.0
TX	5.60	9.17	73.6
MN	5.55	7.54	75.2
IA	6.42	8.32	76.7

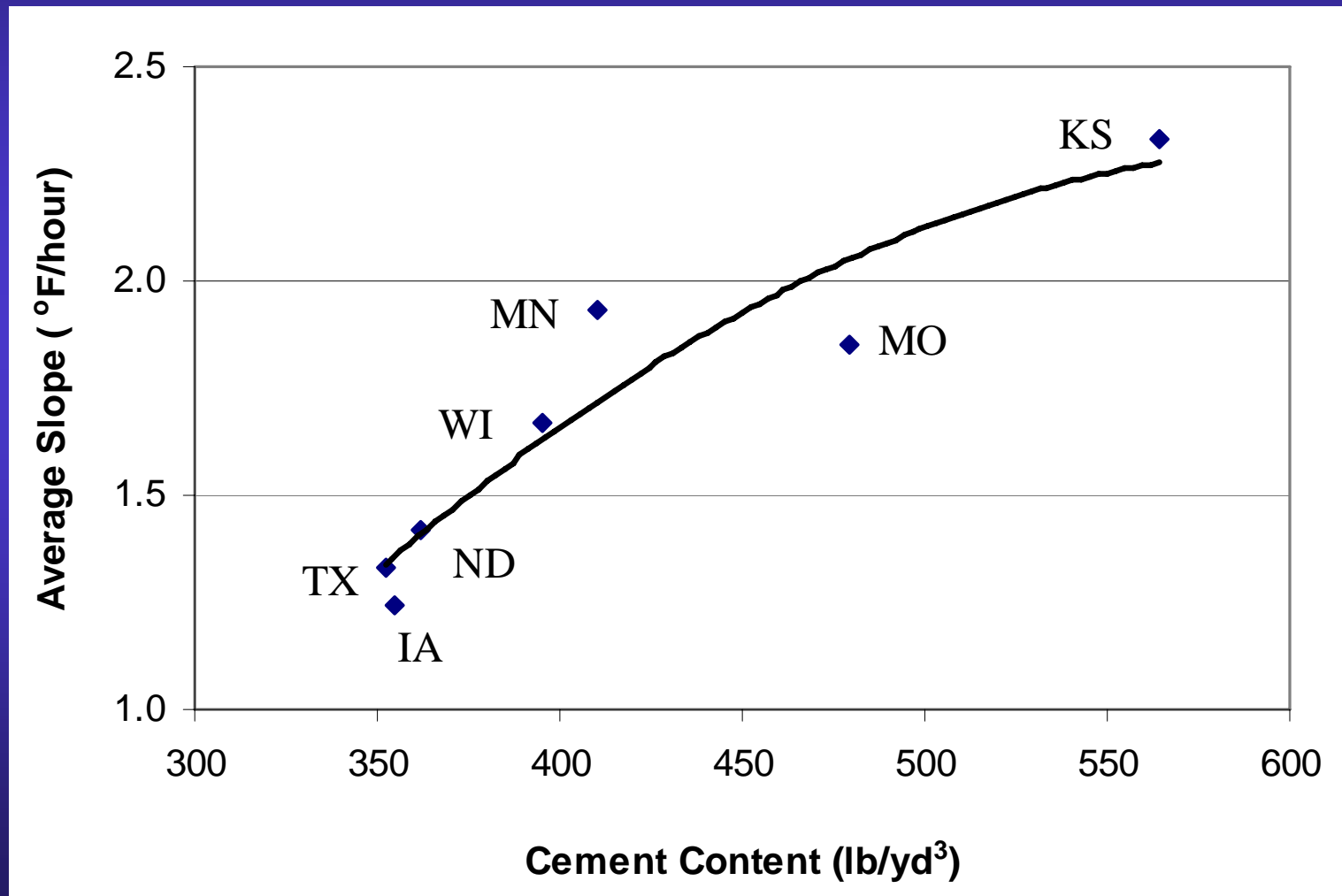
Effect of Alkalis on Initial Setting Time



Correlations Between Heat Evolution and Setting Time



Effect of Cement Content on Heat Evolution



Summary

- The heat evolution results may be able to reflect the change of the mix
- There could be relationship between the average slope and setting time
- More data are necessary to verify these relationships