

Round Robin
ASTM C-642 vs C-1202

September 25, 2007

MCO Meeting

Des Moines, Iowa

Round Robin

- **5 laboratories participated**
- **3 cylinders w/ 5% Silica Fume Boil**
- **3 cylinders w/ 5% Silica Fume Rapid Chloride**
- **3 cylinders w/ 7% Silica Fume Boil**
- **3 cylinders w/ 7% Silica Fume Rapid Chloride**

- **MO-DOT and CTRE-Iowa State**

ASTM C 642 - Density, Absorption, and Voids in Hardened Concrete

Laboratory		5% SF	7% SF
	One	10.1	9.8
	Two	10.3	10.0
	Three	8.9	8.6
	Four	9.7	9.2
	Five	9.2	8.8
	Max	10.3	10.0
	Min	8.9	8.6
	Range	1.4	1.4
	Avg	9.6	9.3
	Range % of Avg	14.5	15.1

ASTM C 1202-97 - Rapid Chloride Ion Permeability Test

Laboratory	5% SF	7% SF
One	2533	2376
Two	2016	1727
Three	1848	1814
Four	2446	2288
Five **	3259	3054
	Max **	3054
	Min	1727
	Range	1327
	Avg	2252
	Range % of Avg	58.9

ASTM C 1202-97 - Rapid Chloride Ion Permeability Test

Laboratory	5% SF	7% SF
One	2533	2376
Two	2016	1727
Three	1848	1814
Four	2446	2288
	Max	2533
	Min	1848
	Range	685
	Avg	2211
	Range % of Avg	31.0
		31.6

Round Robin Equipment

- **3 Testing Machines < 5yrs old Same Manufacturer (Labs 1, 2, and 4)**
- **1 Homemade Machine approx. 15 yrs old. (Lab 3)**
- **1 Four yr old Testing Machine from another Manufacturer. (Lab 5)**

Conclusions?

- **Boil Test is more consistent or less variable between laboratories than the Rapid Chloride Test.**
- **Rapid Chloride Test results may vary dependent on the manufacturer of the equipment.**
- **KDOT is not getting the permeability we want from Silica Fume Overlays.**

**More investigation is needed
into the equipment variability
of ASTM C-1202.**

COMPARISONS

ASTM C-642 vs C-1202

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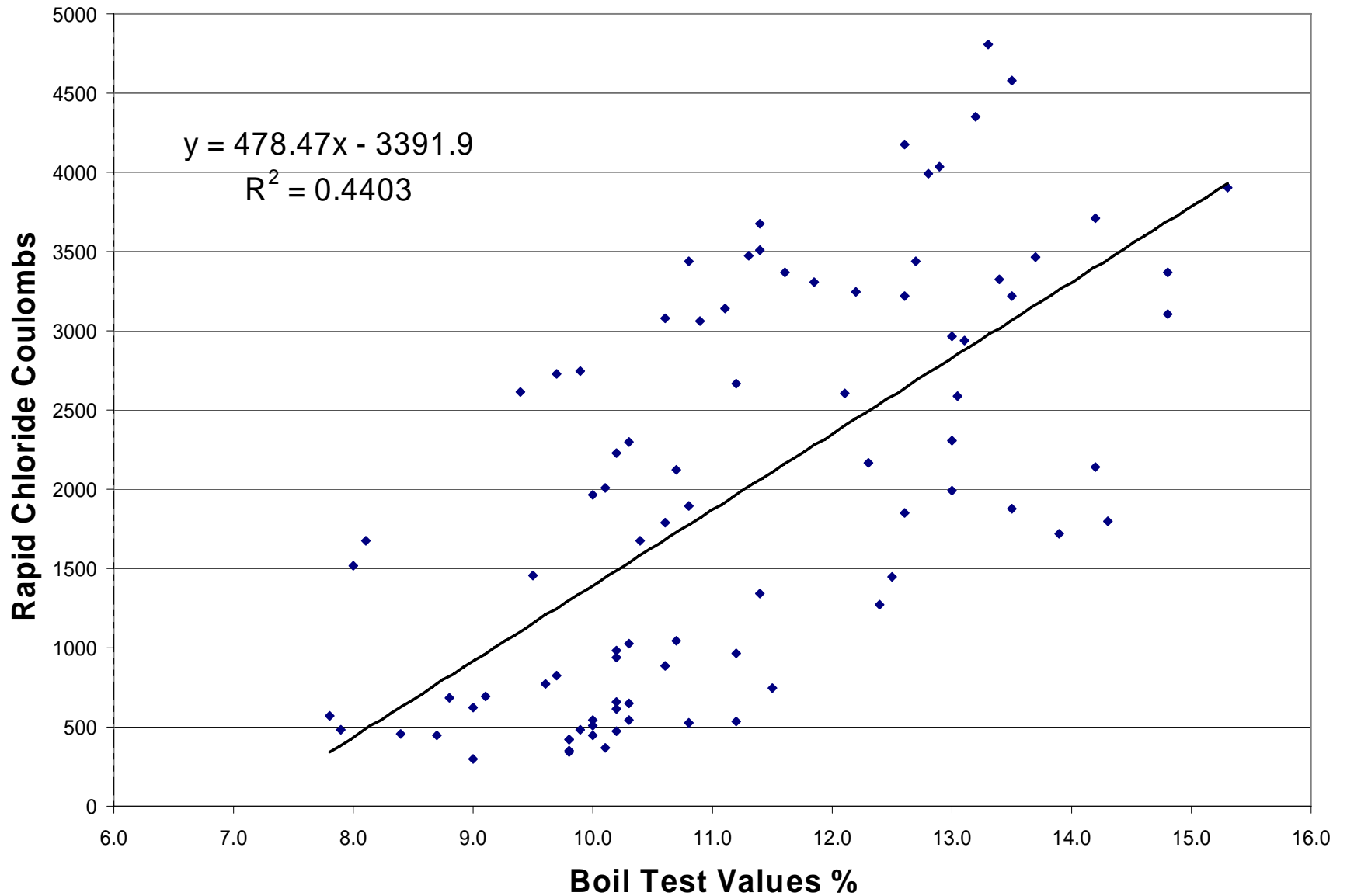
Des Moines, Iowa

Boil vs Rapid Chloride

- 88 sets of data so far
- 22 sets of data to still complete
- Granite, Calcite Cemented Sandstone, Limestone, Sand Gravels, Quartzite
- Slag, C-Fly Ash, F-Fly Ash, Silica Fume
- Various Cement Factors and w/c ratios

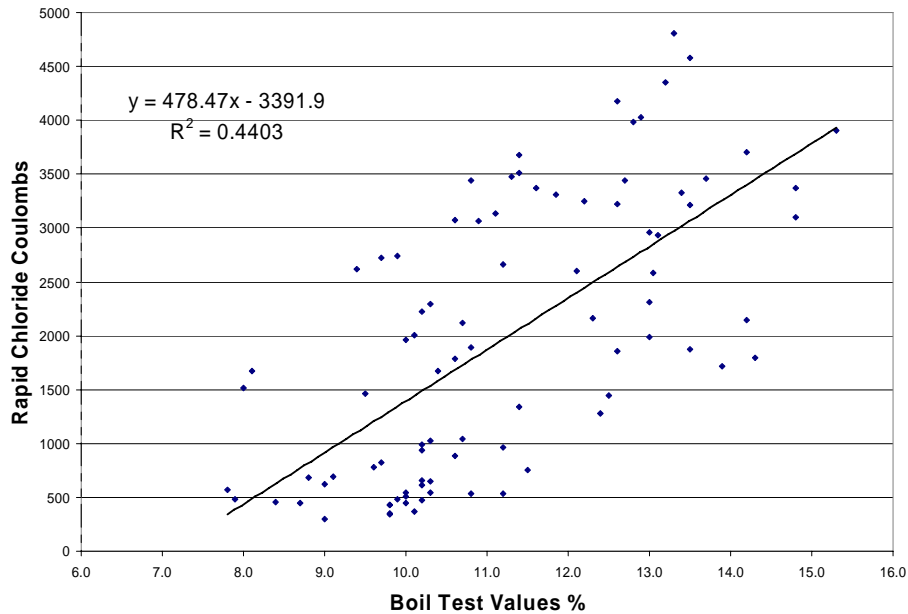
- Every possible KDOT Mix?

Boil vs Rapid Chloride All Data

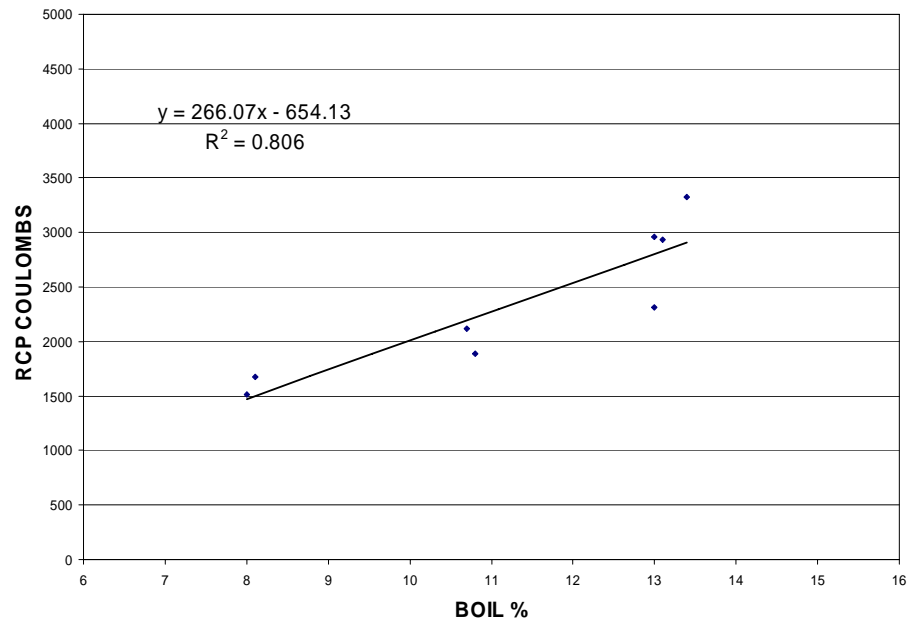


All Data vs Quartzite Single Source

Boil vs Rapid Chloride All Data

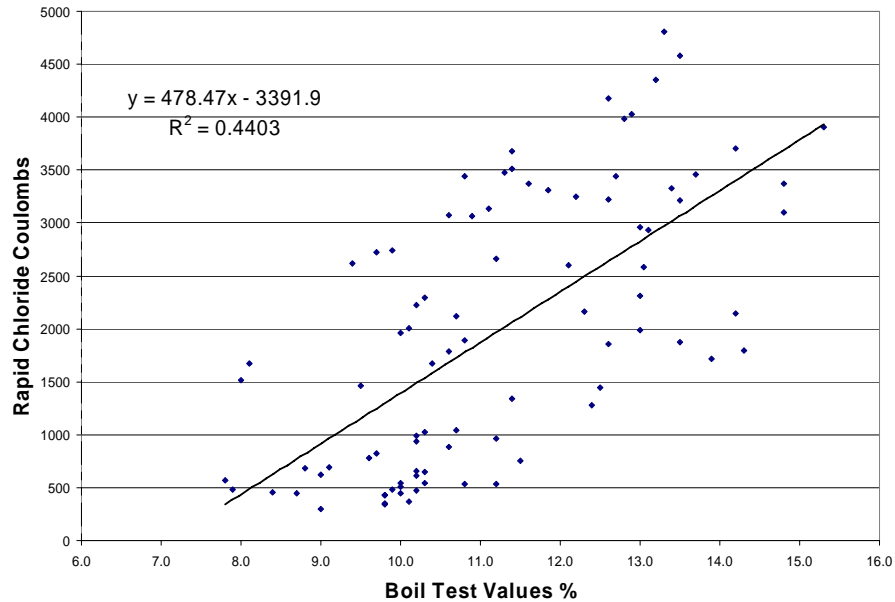


BOIL VS RCP - QUARTZITE

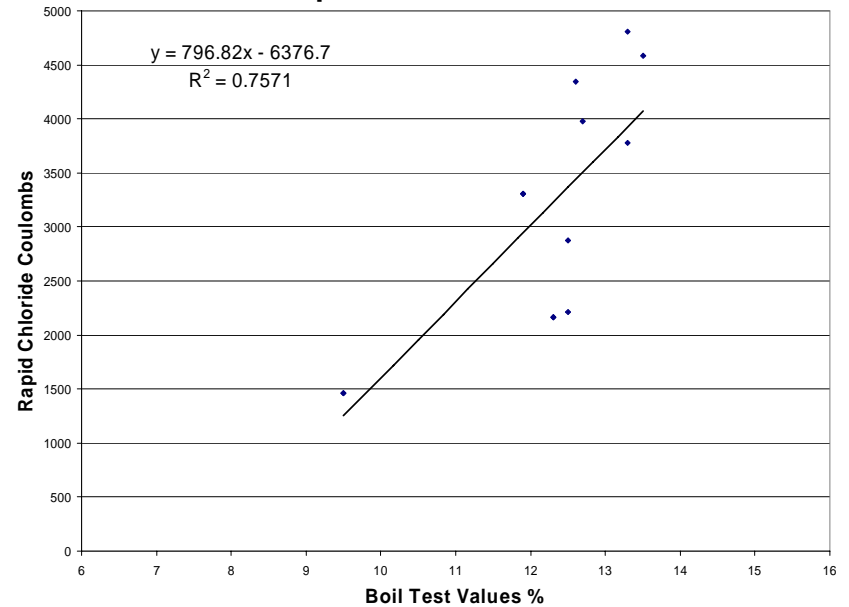


All Data vs Limestone 4 Sources

Boil vs Rapid Chloride All Data



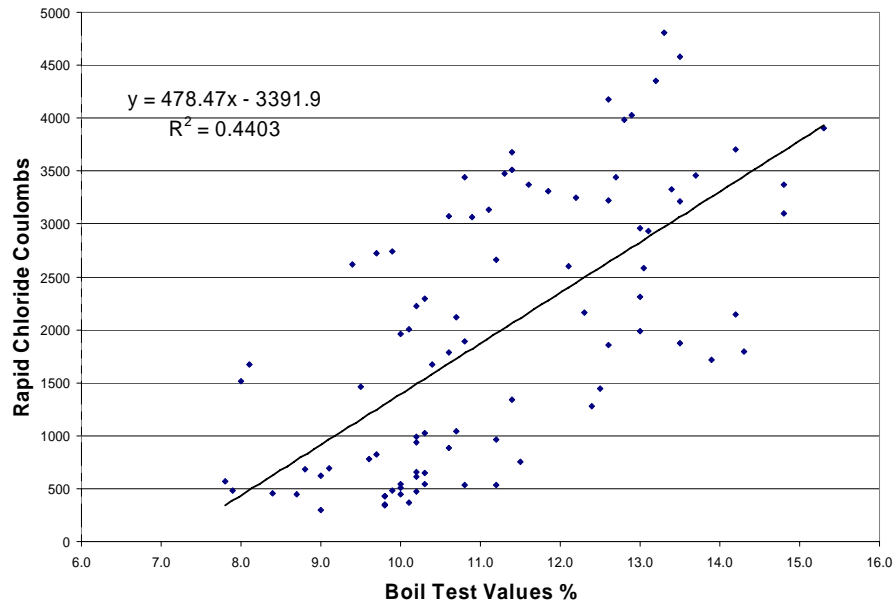
Boil vs Rapid Chloride Limestone



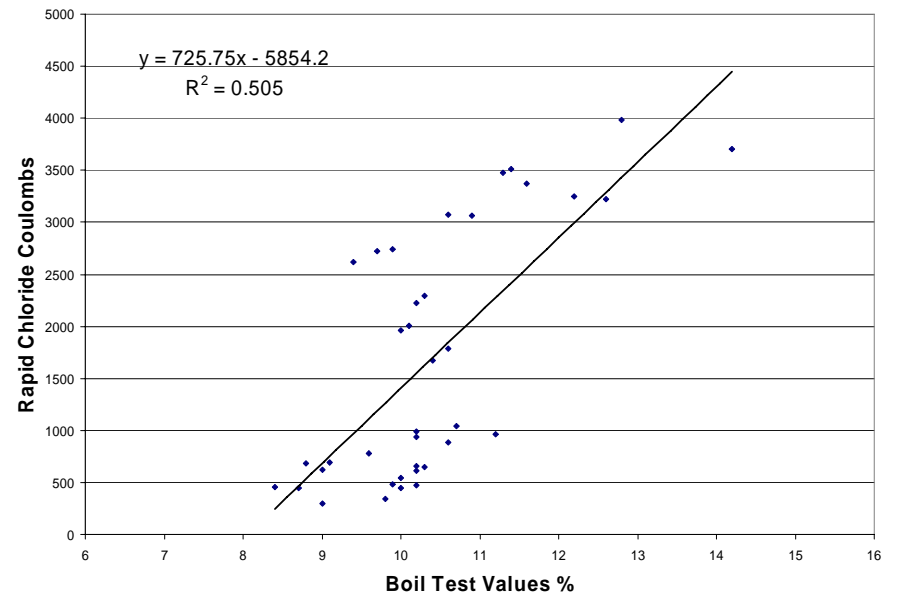
All Data vs All Granites

2 Sources

Boil vs Rapid Chloride All Data

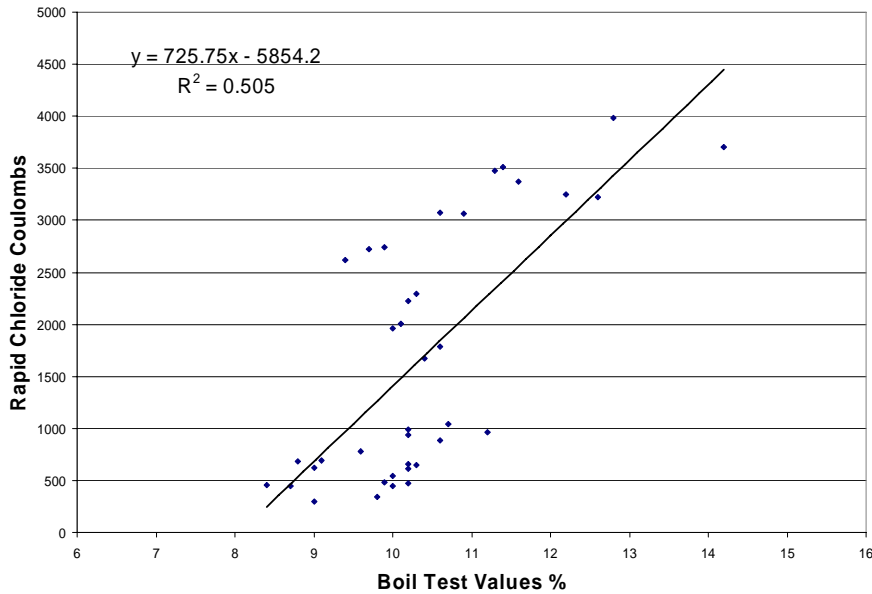


Boil vs Rapid Chloride All Granites

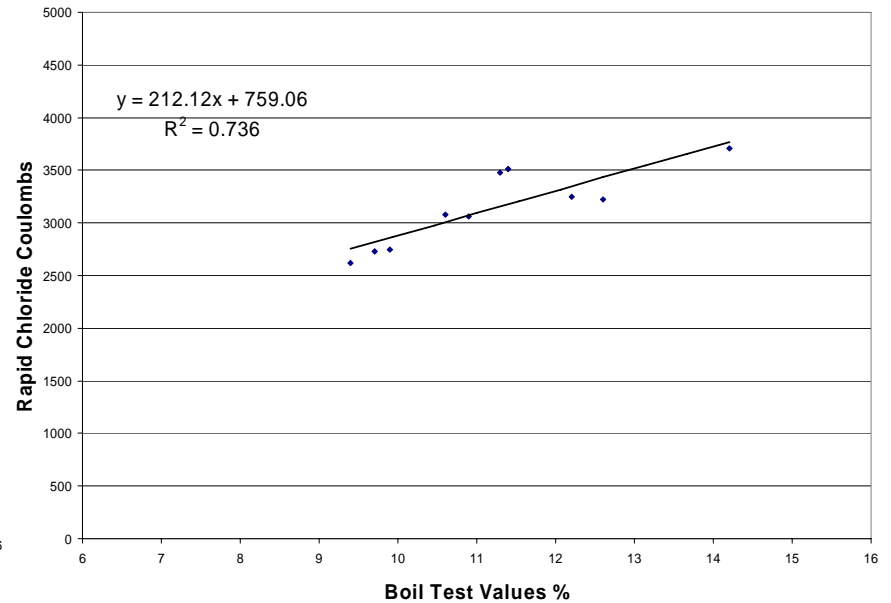


All Granite vs Granite w/o SCM Single Source

Boil vs Rapid Chloride All Granites

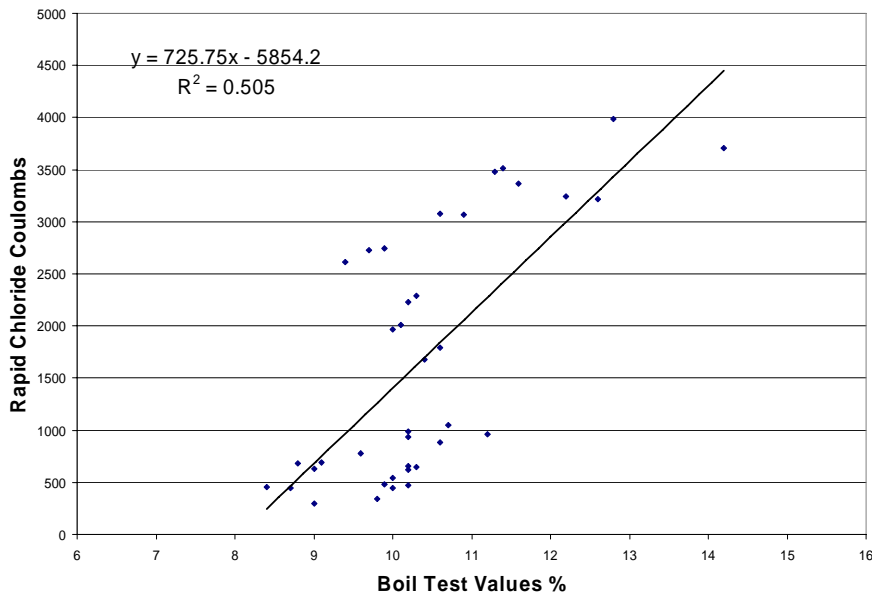


Boil vs Rapid Chloride Granite w/o SCM

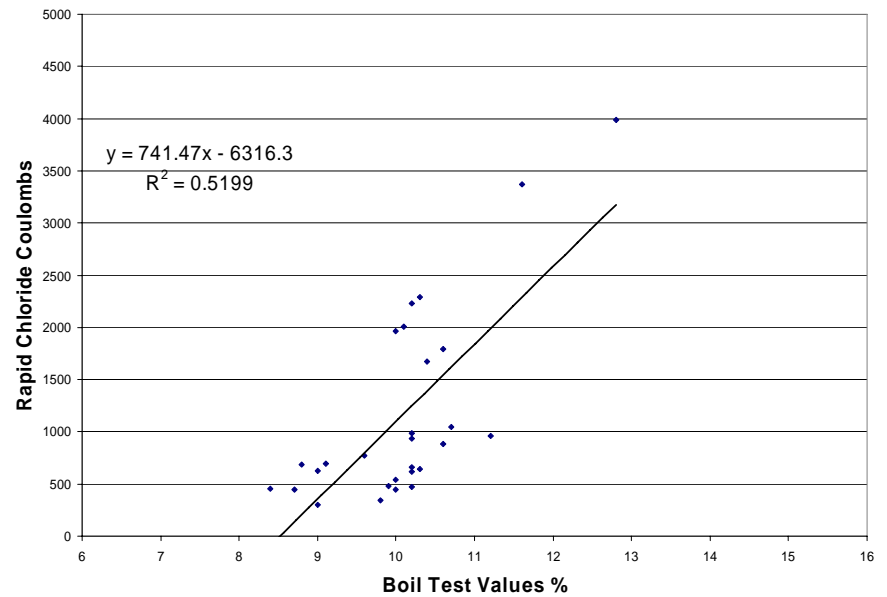


All Granite vs Granite w/ SCM Single Source

Boil vs Rapid Chloride All Granites

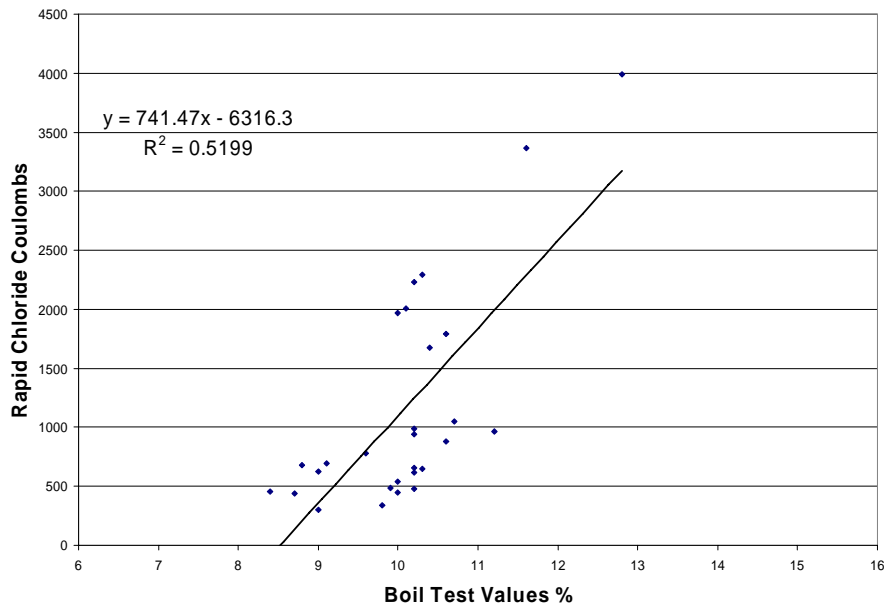


Boil vs Rapid Chloride Granite w/SCM

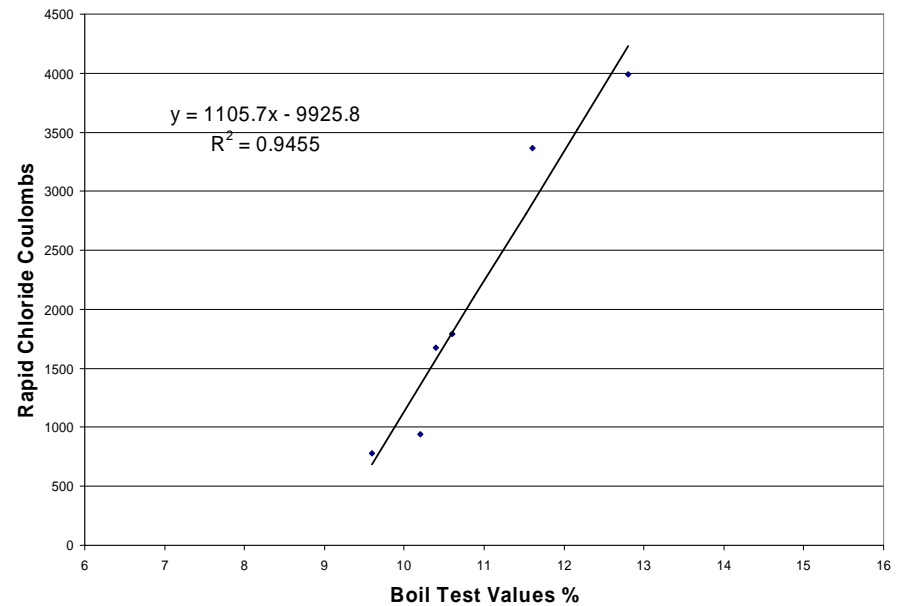


Gran w/ SCM vs Gran w/ Slag Single Source

Boil vs Rapid Chloride Granite w/SCM

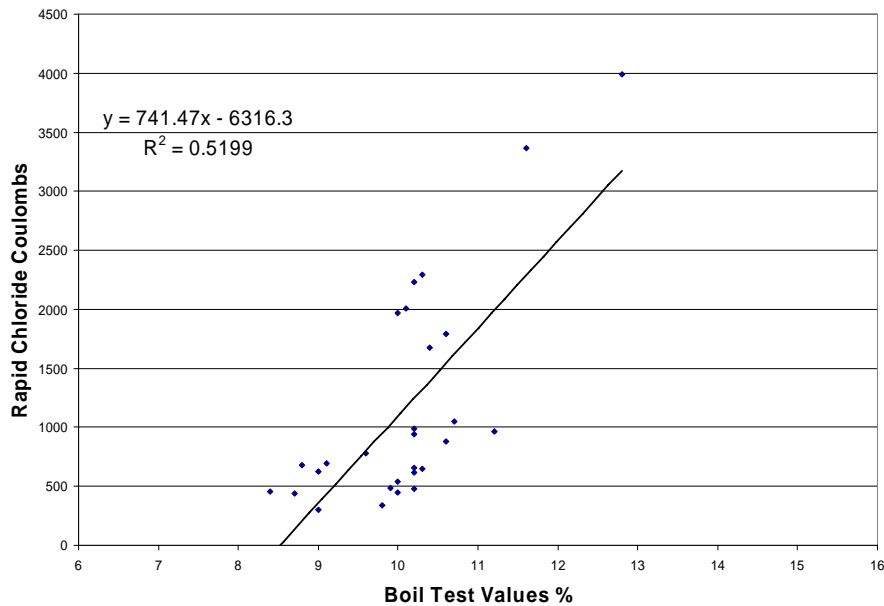


Boil vs Rapid Chloride Granite w/ Slag

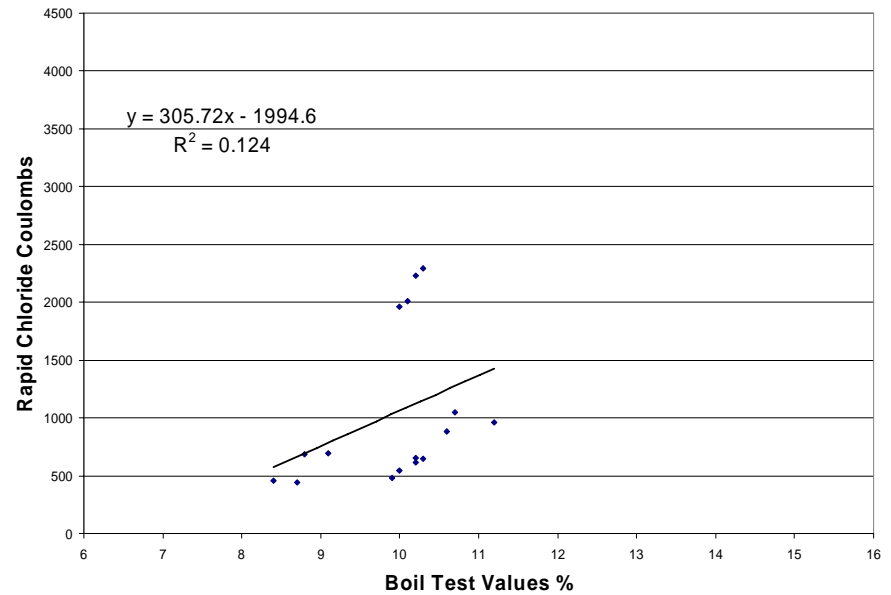


Gran w/ SCM vs Gran w/ Silica Fume Single Source

Boil vs Rapid Chloride Granite w/SCM

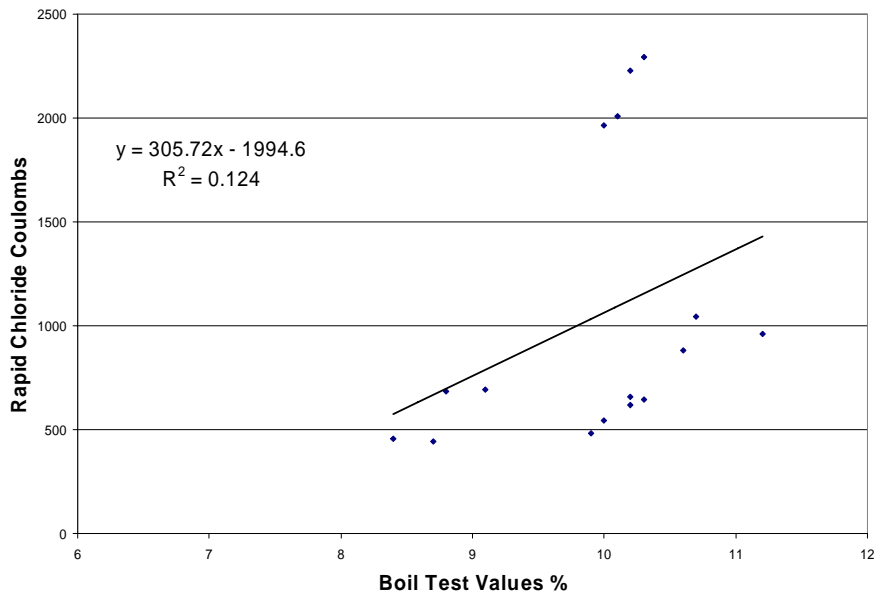


Boil vs Rapid Chloride Granite w/ SF

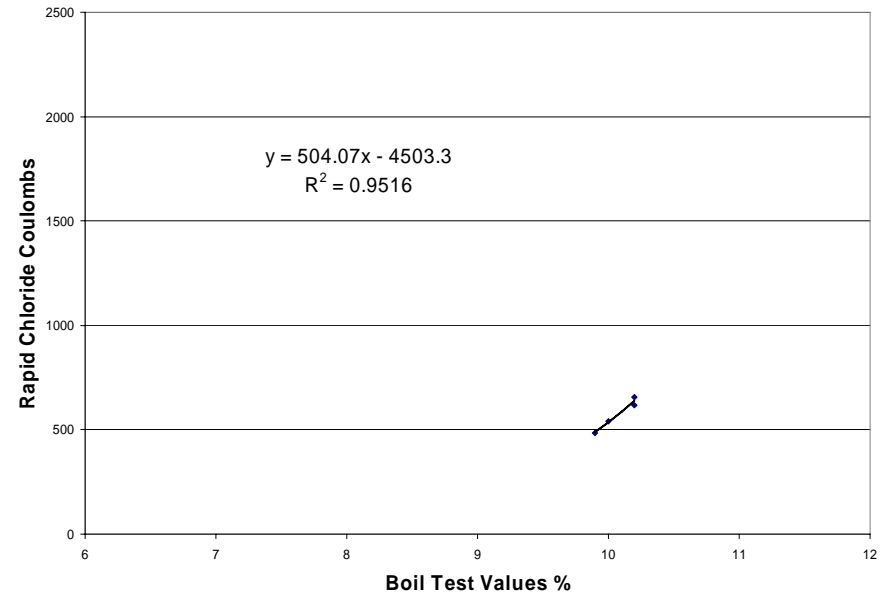


All Granite w/ Silica Fume vs Silica Fume 535 lbs Cement

Boil vs Rapid Chloride Granite w/ SF

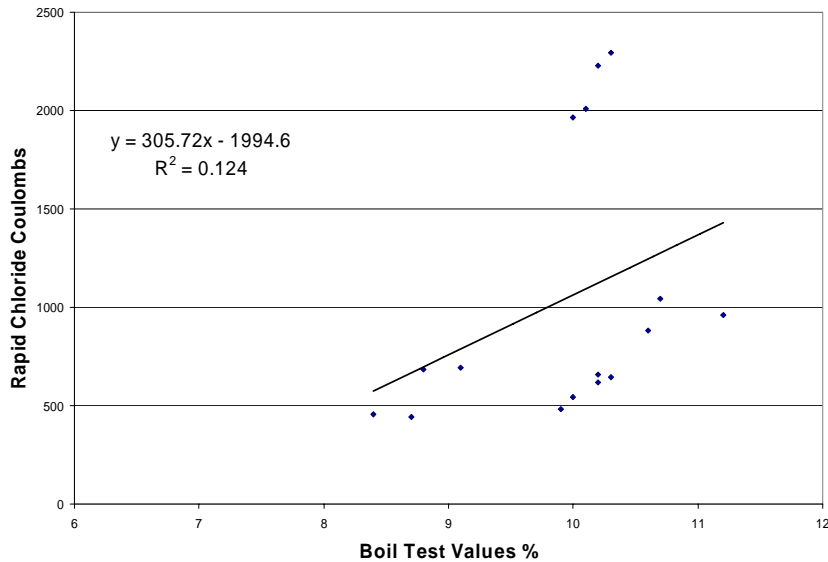


Silica Fume @ 535 lbs Cement

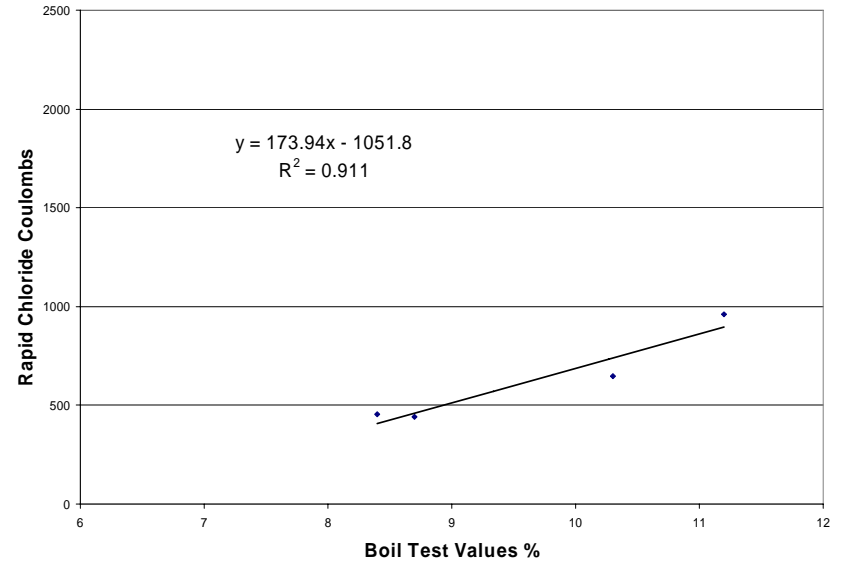


All Granite w/ Silica Fume vs Silica Fume 625 lbs Cement

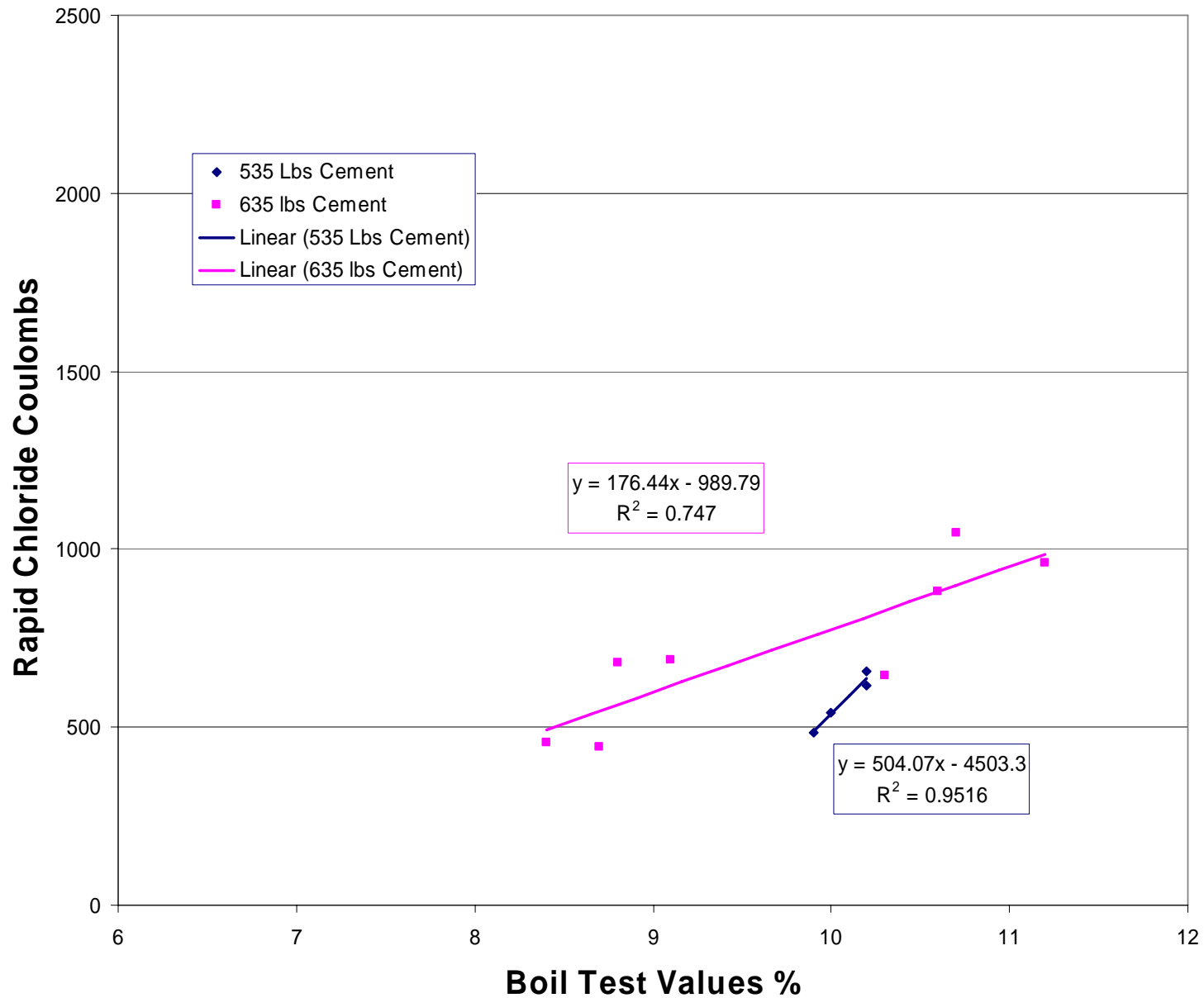
Boil vs Rapid Chloride Granite w/ SF



Granite w/ Silica Fume 625 lbs Cement

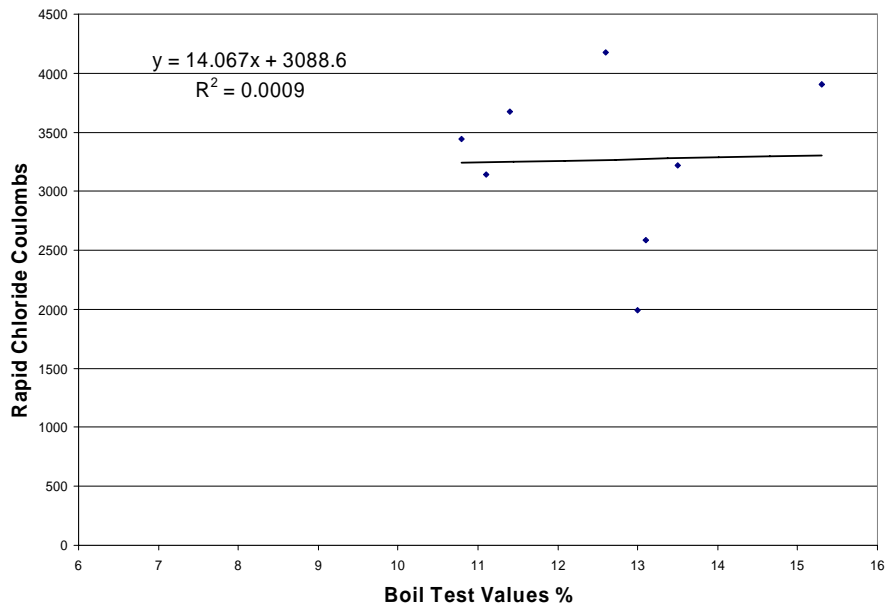


Boil vs Rapid Chloride Granite w/ Silica Fume Data

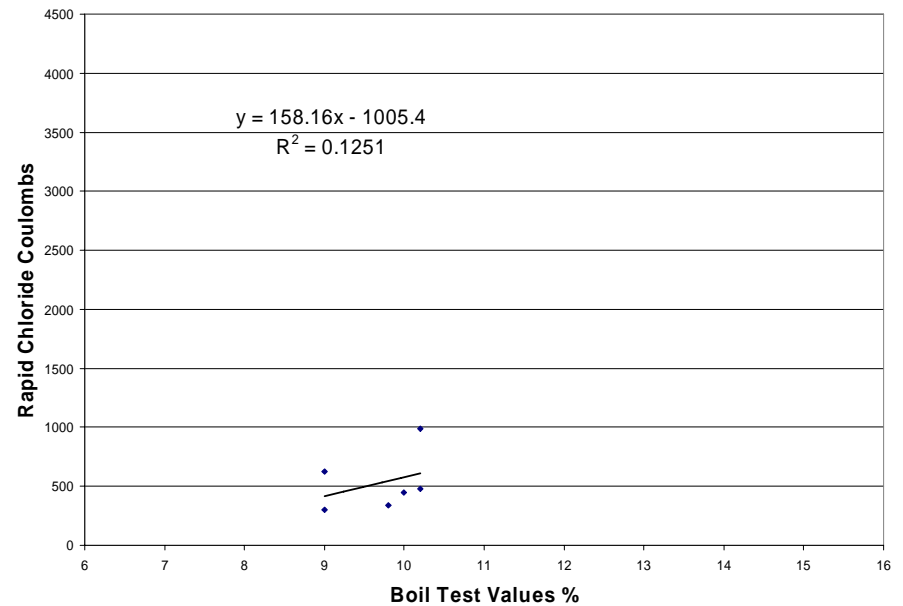


Need More Data?

Boil vs Rapid Chloride Sand Gravels

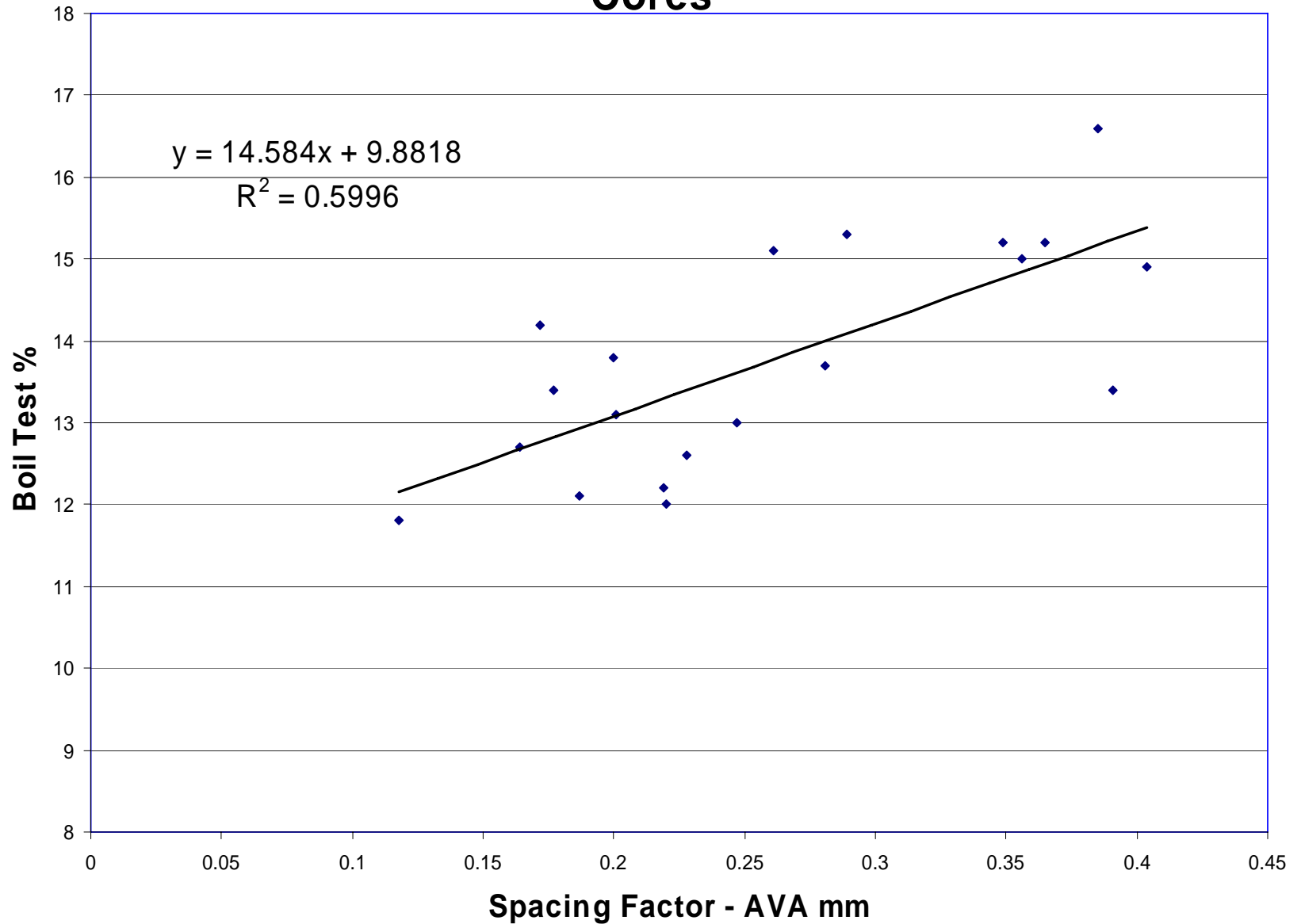


Boil vs Rapid Chloride Granite w/ F-Ash



	Boil	
AVA	Top 2"	RCP
0.385	16.6	N/A
0.289	15.3	3904
0.365	15.2	N/A
0.349	15.2	N/A
0.261	15.1	N/A
0.356	15.0	N/A
0.404	14.9	N/A
0.172	14.2	3707
0.200	13.8	N/A
0.281	13.7	3463
0.391	13.4	N/A
0.177	13.4	3328
0.201	13.1	2936
0.247	13.0	2310
0.164	12.7	3438
0.228	12.6	3221
0.219	12.2	3247
0.187	12.1	N/A
0.220	12.0	N/A
0.118	11.8	N/A

Spacing Factor (AVA) vs Boil Test % Cores



Boil Tests		
Cylinder		Top %
Top	Middle	Higher
11.3	11.4	-0.9
8.1	8.0	1.3
13.5	13.3	1.5
7.8	7.9	-1.3
10.3	9.7	6.2
9.1	8.8	3.4
8.7	8.4	3.6
10.3	10.2	1.0
10.0	10.1	-1.0
14.3	13.9	2.9
14.8	14.8	0.0
10.1	9.8	3.1
9.8	9.8	0.0

Average **1.5**

Max **6.2**

Min **-1.3**

Boil Tests		
Core		Top %
Top	Middle	Higher
10.2	10.0	2.0
9.8	9.0	8.9
12.0	11.5	4.3
12.2	11.6	5.2
11.1	10.8	2.8
12.1	11.5	5.2
18.1	15.1	19.9
13.8	12.9	7.0
15.3	13.5	13.3
	Average	7.62
	Max	19.87
	Min	2.00

Boil Tests		
Cylinder		Top %
Top	Bottom	Higher
10.6	9.4	12.8
10.2	10.2	0.0
9.6	9.0	6.7
12.1	11.8	2.5
12.0	11.9	0.8
10.2	10.0	2.0
10.2	9.9	3.0
10.7	10.6	0.9
10.3	10.0	3.0
11.2	10.8	3.7
12.5	12.4	0.8
11.4	12.6	-9.5
11.9	12.8	-7.0
16.0	13.9	15.1
12.6	11.2	12.5

Average

3.2

Max

15.1

Min

-9.5

Boil Tests		
Core		Top % Higher
Top	Bottom	
12.2	9.9	23.2
10.9	9.7	12.4
13.7	13.2	3.8
10.6	9.4	12.8

Average

13.0

Max

23.2

Min

3.8

Boil Test		
Cylinder	Core	Cyl as a
Top	Top	% Core
9.6	9.8	98.0
10.2	10.2	100.0
10.6	10.9	97.2
11.3	12.2	92.6
11.4	11.1	102.7
11.9	12.1	98.3
12.0	12.2	98.4
12.1	12.0	100.8
12.6	13.8	91.3
13.5	13.7	98.5
16.0	18.1	88.4
	Average	96.9
	Max	102.7
	Min	88.4

Rapid Chloride Cylinders		
Top	Middle	Top as % Middle
3475	3512	98.9
1676	1516	110.6
4583	4807	95.3
568	483	117.6
1026	825	124.4
691	683	101.2
443	456	97.1
2294	2228	103.0
1965	2007	97.9
1799	1719	104.7
3104	3368	92.2
367	352	104.3
425	425	100.0

Average 103.6

Max 124.4

Min 92.2

Rapid Chloride Cylinders		
Top	Bottom	Top as % Middle
3077	2618	117.5
938	986	95.1
776	626	124.0
658	542	121.4
617	484	127.5
1046	882	118.6
540	510	105.9
537	530	101.3
1445	1275	113.3
3677	4174	88.1

Average 111.3

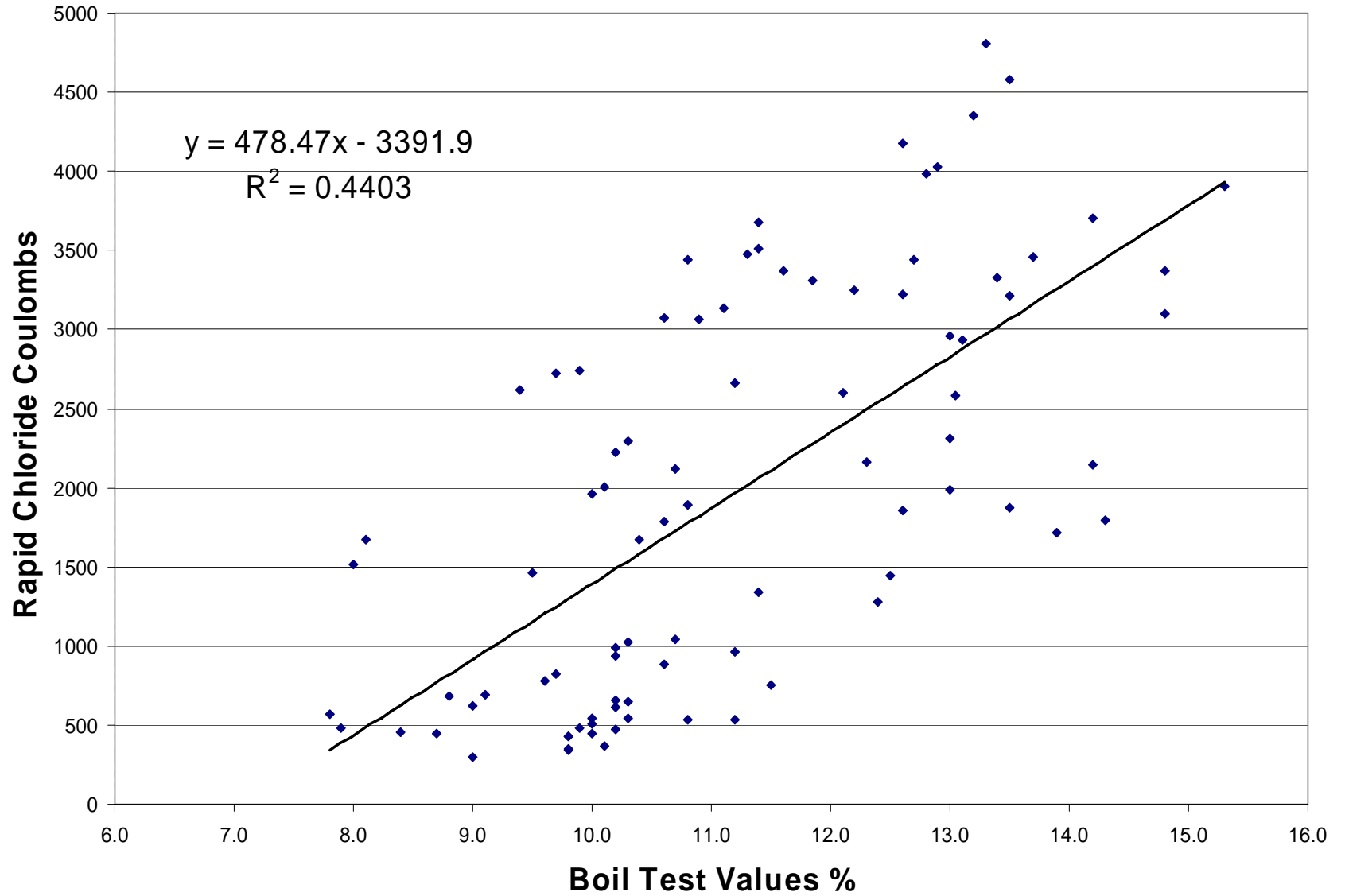
Max 127.5

Min 88.1

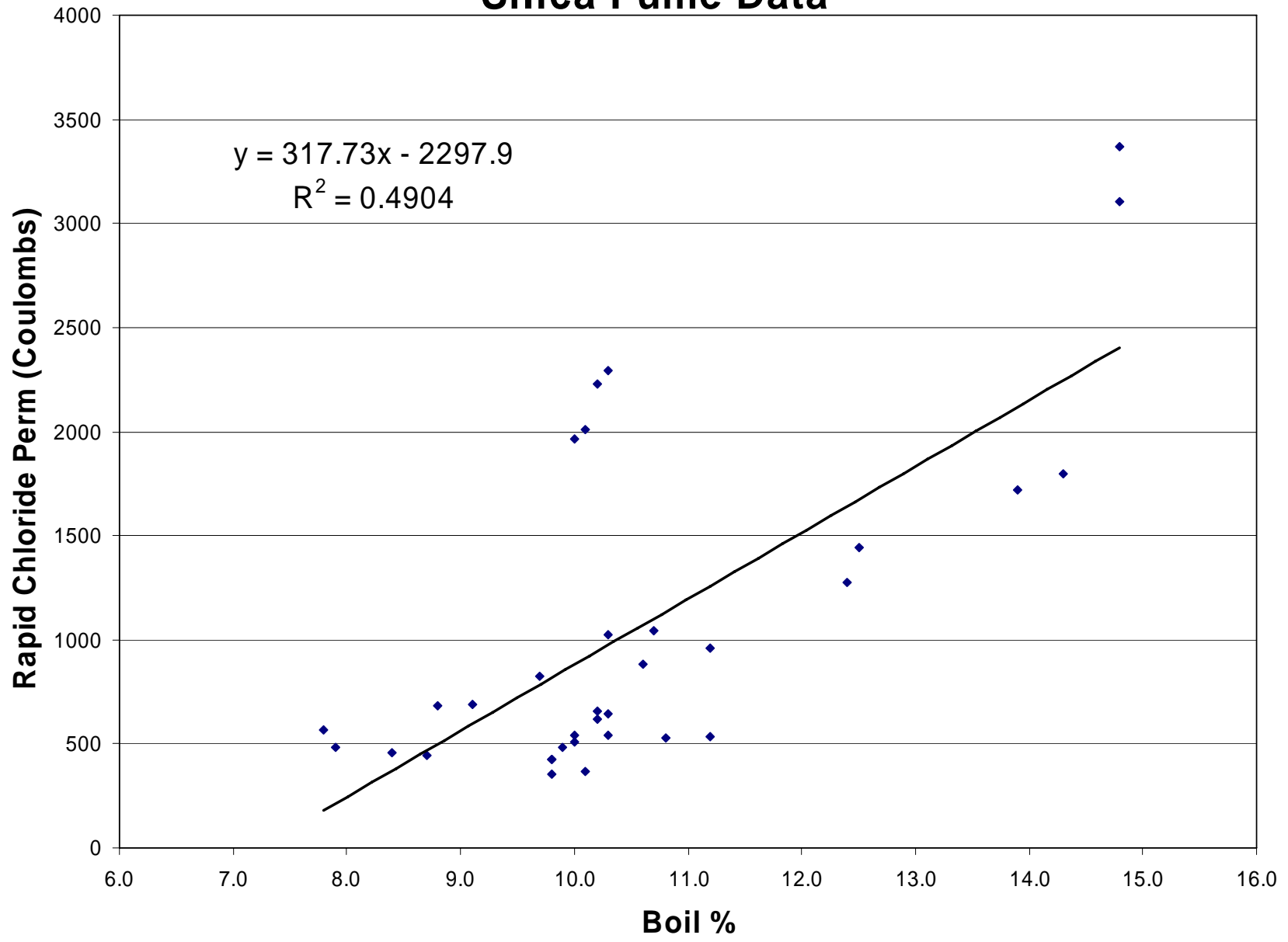
Rapid Chloride Cores		
Top	Middle	Top as % Middle
3247	2743	118.4
3064	2727	112.4
475	445	106.7
341	300	113.7
3138	3439	91.2
3904	3218	121.3
	Average	110.6
	Max	121.3
	Min	91.2

Rapid Chloride Perms		
Cylinder	Cores	Cylinder as a
Top 2"	Top 2"	% of Core
3475	3247	107.0
3077	3064	100.4
938	475	197.5
776	341	227.6
4583	3463	132.3
3677	3138	117.2
	Average	147.0
	Max	227.6
	Min	100.4

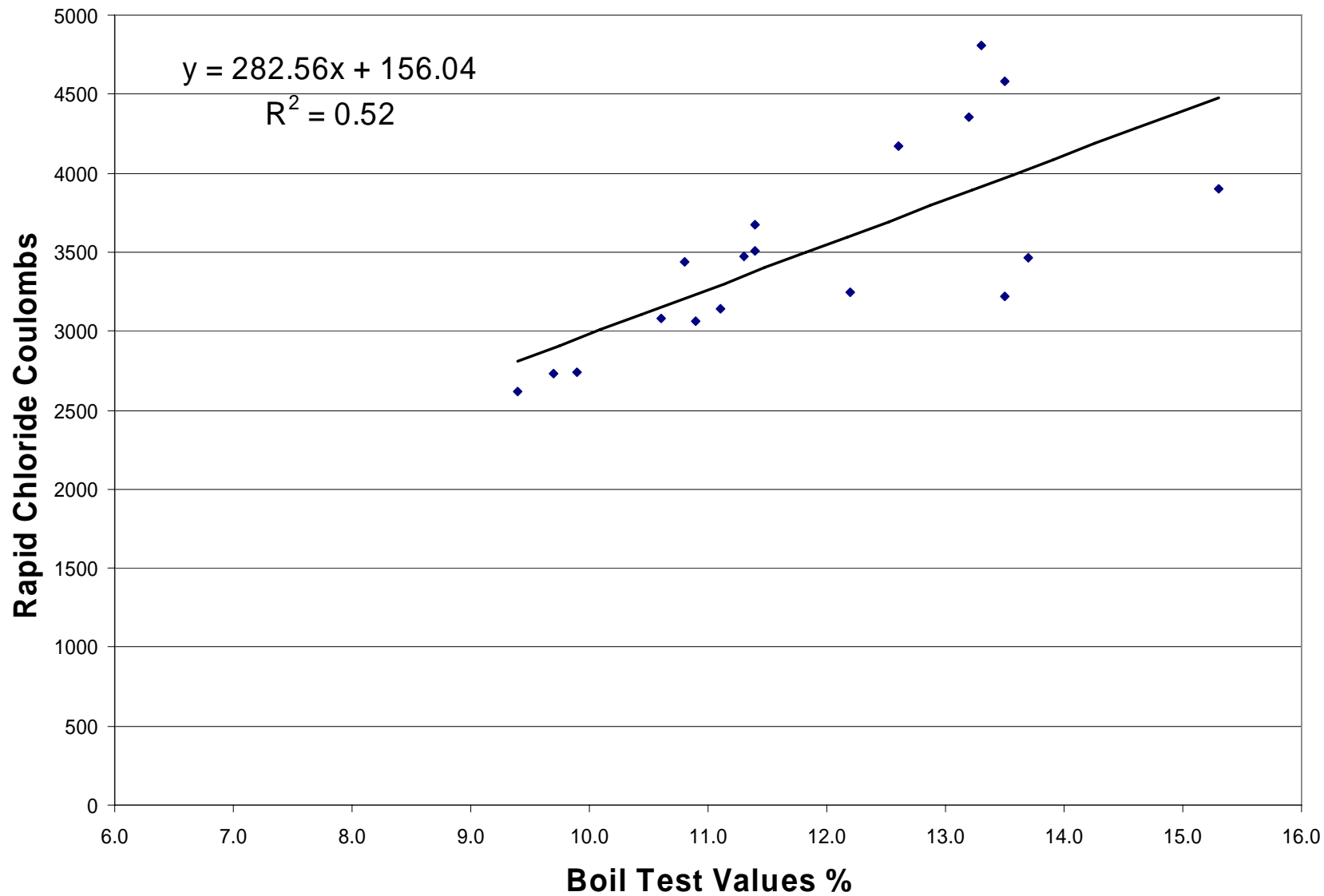
Boil vs Rapid Chloride All Data



Boil vs Rapid Chloride Perm Silica Fume Data



Boil vs Rapid Chloride Pavements



Conclusions

- **Aggregate Type, SCMs, and Amount of Cement all affect the comparisons between the Boil and the Rapid Chloride Tests.**
- **The affect can be defined by looking at one variable at a time.**

Conclusions

- **There appears to be a correlation between spacing factor measured by the AVA and test results from the boil test.**
- **This will be further investigated.**

Conclusions

- **The top 2” of both Cylinders and Cores tend to have higher Boil Values than the rest of the cylinder or core.**
- **The top 2” of both Cylinders and Cores tend to have higher Rapid Chloride Perm Values than the rest of the cylinder or core.**

Conclusions

- **The top 2” of cylinders tend to have lower Boil Values than the top 2” of the cores made from the same concrete.**
- **The top 2” of cylinders tend to have higher Rapid Chloride Perm Values than the top 2” of the cores made from the same concrete.**