CHARITON VALLEY BIOMASS PROJECT

Task 6.1.1, Phase 2

Testing Program for Evaluation of Co-combustion Fly Ash Produced at Ottumwa Generating Station

Final Report Presentation

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Background

- **Purpose** - testing was conducted to evaluate the chemical and physical properties of fly ash produced during the co-combustion of coal and switchgrass at OGS
- **Scope** - testing consisted of both ASTM C 618 tests and concrete tests
- **Goal** - to provide the technical information needed to convince users that co-combustion fly ash is a viable component of concrete mixtures

Background – fly ash samples

- Significant quantities of fly ash were collected for the second co-combustion trial burn; this was a major improvement over the first trial burn
- Several of the ash samples were obtained from the ash silo and these samples were representative of “marketable” fly ash

Samples from ash silo

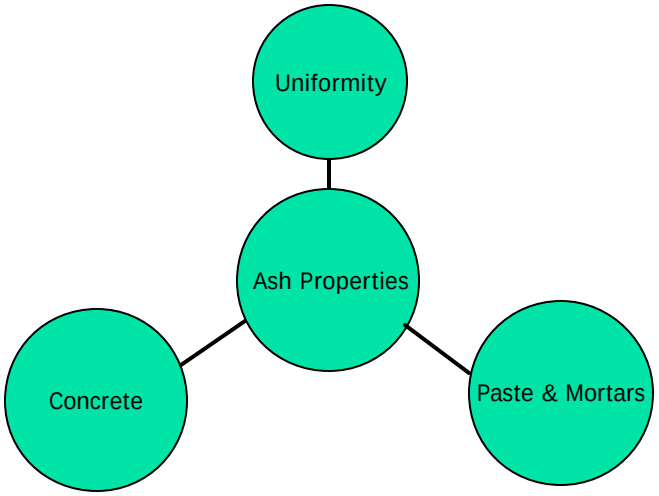
- Silo fly ash samples were collected during baseline (coal only) and co-combustion of coal and switchgrass
- Samples were denoted as:
  - OGS112103 (baseline, ASH1)
  - OGS121003 (ASH2)
  - OGS121103 early day (ASH3)
  - OGS121103 late day (ASH4)

Samples from autosampler

- Fly ash samples were collected throughout the trial burn by means of an autosampler
- A total of 12 samples were collected for this study
- Each sample had a mass of about 2 kilos (3 to 4 pounds)

- 112503
- 120103
- 120303
- 120403
- 120503
- 120603
- 120803
- 120903
- 121003
- 121103
- 121203

Desired Testing Program



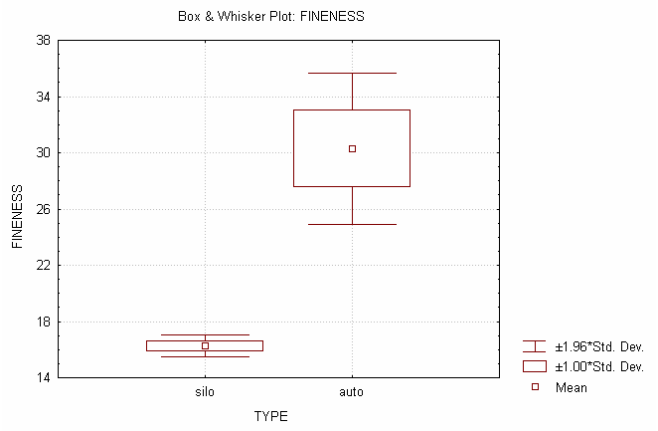
Results – Materials Properties

- ✓ Bulk chemistry of all sixteen fly ash samples met the requirements of ASTM C 618 for Class C fly ash
- ✓ X-ray diffraction indicated that the crystalline compounds and the glass content were very similar for the baseline and co-combustion ash samples obtained from the silo

Autosampler vs Silo Ash

- The autosampler collected fly ash samples that had fineness values significantly different from samples of fly ash that were obtained from the silo
- This appeared to be due to a timing error on the autosampler collection program – it should be adjusted to give better agreement between samples

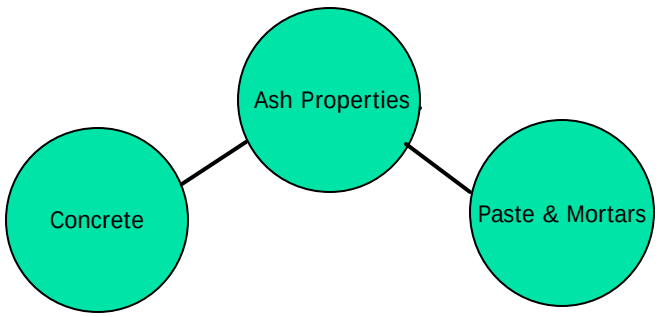
Ash sampling problem



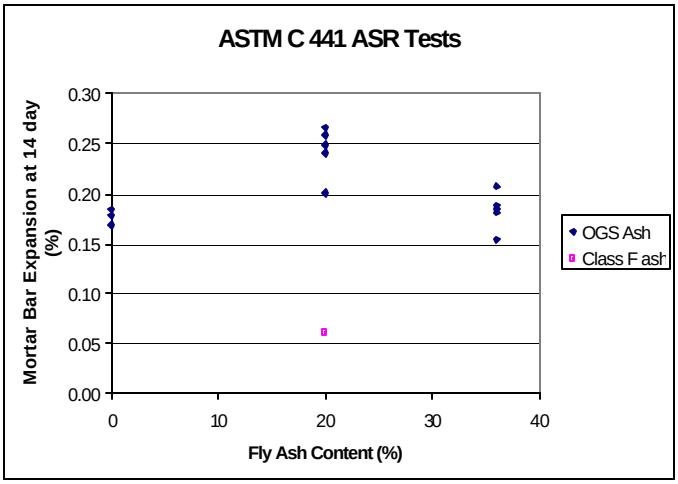
Changes in testing plan due to sampling problems

- Concrete testing plan was not changed
- All four silo ash samples were tested in accordance with ASTM C 618 and then concrete mixtures were made
- Paste and mortar sample testing plan was changed
- Samples from the autosampler were only subjected to bulk chemical testing, fineness and strength index tests

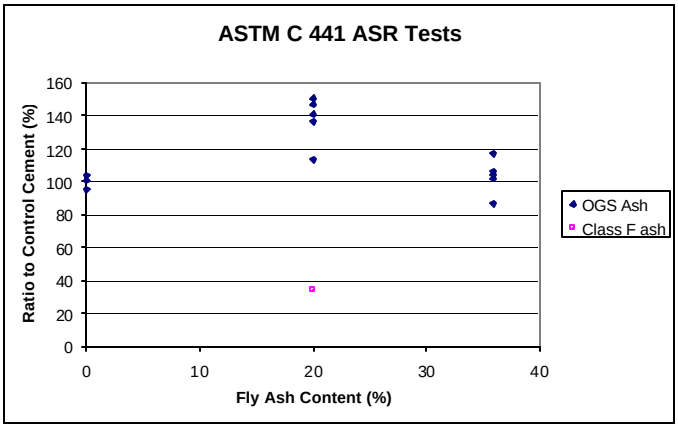
Actual Testing Program



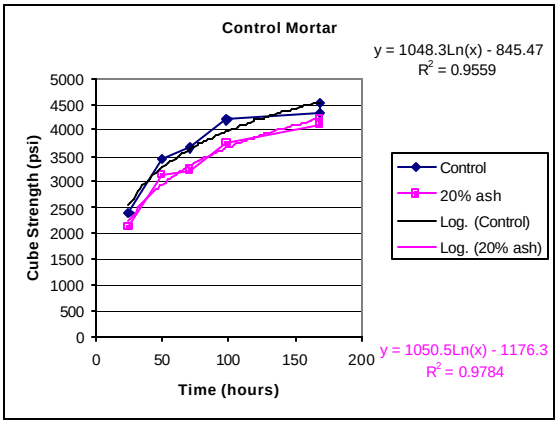
Mortar bar expansion for ASR



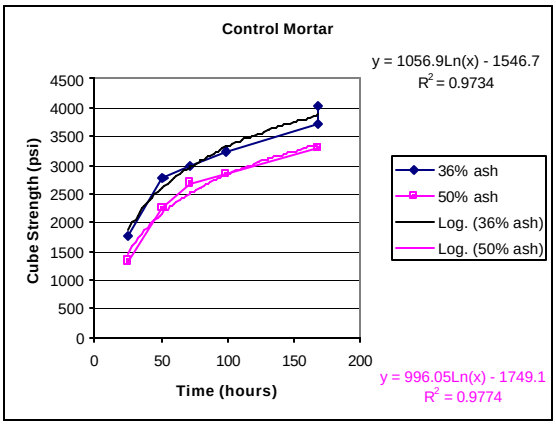
Results – ASR Performance



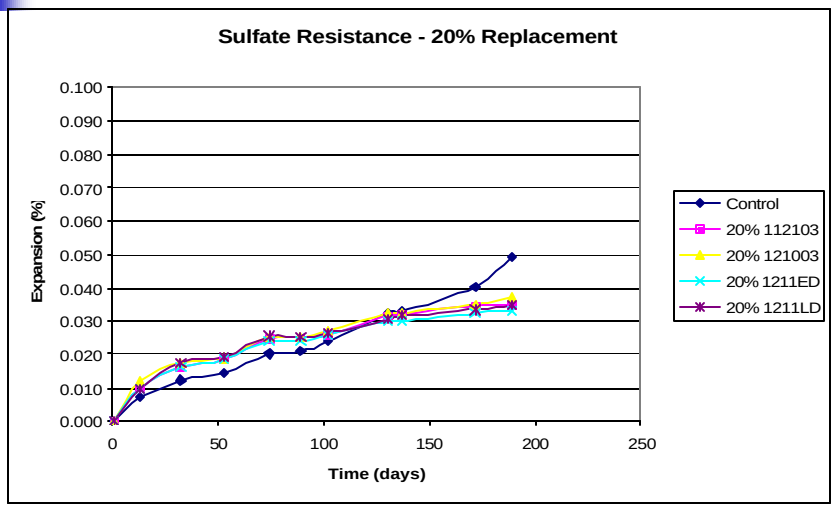
Early Strength Gain - mortars



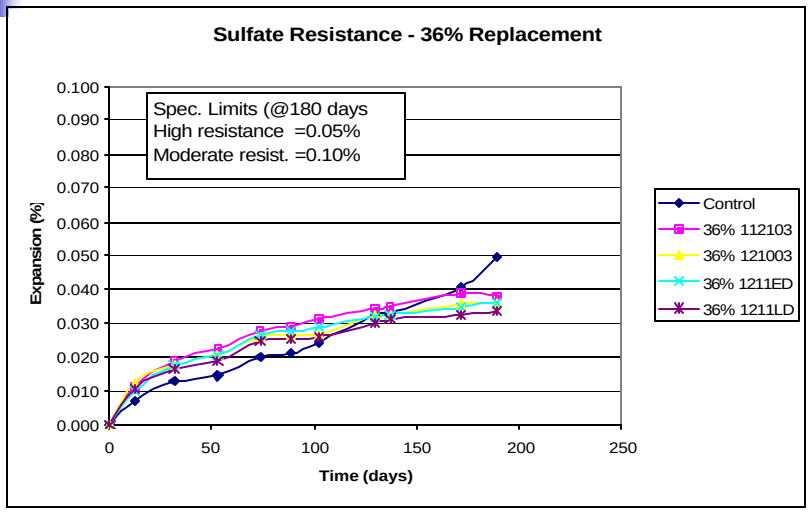
Early Strength Gain - mortars



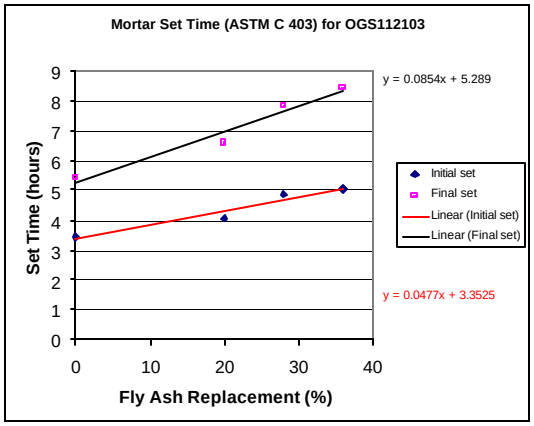
Sulfate Resistance – 20 % ash



Sulfate Resistance – 36% ash



Setting time vs Ash Content



Results – Materials Properties

- ✓ All four of the silo fly ash samples met the mandatory chemical and physical requirements specified for Class C fly ash in ASTM C 618
- ✓ Only small differences were noted between the baseline sample and the co-combustion samples

Results – Performance Tests

- Sulfate resistance tests exhibited good performance (all mixtures <0.05% expansion in 6 months)
- ASR tests indicated that OGS fly ash needed to be used at replacement levels of at least 36% if one desired to reduce expansion to the level of the low alkali control cement (this is in good agreement with prior ASR testing that was conducted on OGS fly ash)

Concrete Mixtures

- Concrete tests were conducted to evaluate how the co-combustion ash would perform in typical concrete applications
- Mix design was based on an Iowa DOT C-3-20C mixture (600 lbs cement, 0.43 nominal water/cement ratio)
- Fly ash content was varied from 20% to 36% by mass of cement

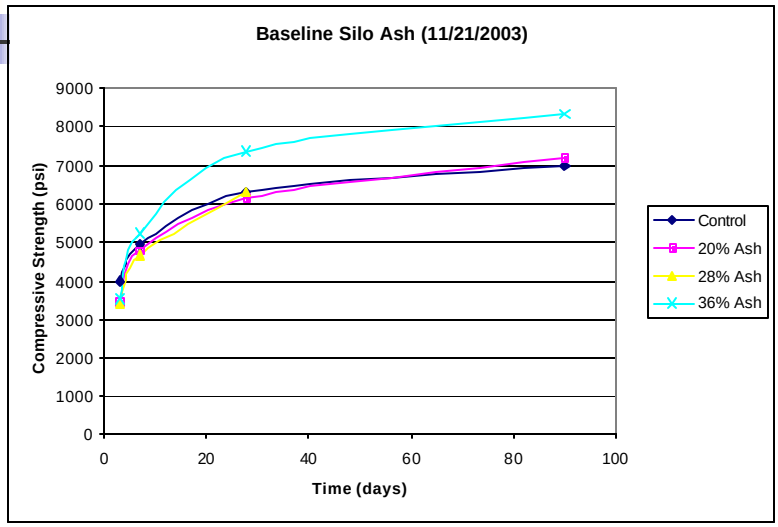
Concrete Mixtures: summary of plastic properties

Mix #	Mix Info.	% Ash	Slump (inches)		Slump	Unit wt.	Air%
			0min	30min	Loss, in.	(pcf)	
0	Control	0	2.25	1.50	0.75	143.0	5.1
1	Ash 1-20%	20	3.25	2.00	1.25	142.8	5.2
2	Ash 1-28%	28	2.50	1.50	1.00	143.2	5.2
3	Ash 1-36%	36	2.50	1.25	1.25	142.0	4.0
4	Ash 2-20%	20	2.50	1.25	1.25	141.8	5.7
5	Ash 2-28%	28	2.50	1.25	1.25	141.4	6.3
6	Ash 2-36%	36	2.75	1.25	1.50	140.8	6.5
7	Ash 3-20%	20	2.50	1.50	1.00	141.6	6.0
8	Ash 3-28%	28	3.50	1.75	1.75	140.0	6.8
9	Ash 3-36%	36	2.50	1.25	1.25	140.6	6.6
		Maximum	3.50	2.00	1.75	143.20	6.80
		Minimum	2.25	1.25	0.75	140.00	4.00

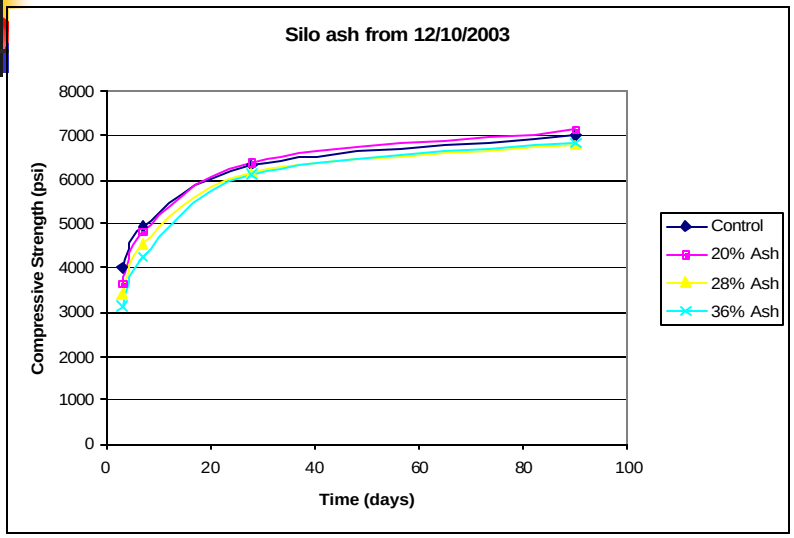
Concrete Mixtures: compressive strength summary

Mix#	Mix Info.	% Ash	3 days	7 days	28 days	90 days
			(psi)	(psi)	(psi)	(psi)
0	Control	0	3998	4946	6322	6990
1	Ash 1-20%	20	3473	4781	6169	7210
2	Ash 1-28%	28	3403	4689	6294	7070
3	Ash 1-36%	36	3541	5250	7374	8360
4	Ash 2-20%	20	3616	4820	6373	7140
5	Ash 2-28%	28	3401	4547	6142	6800
6	Ash 2-36%	36	3112	4239	6105	6810
7	Ash 3-20%	20	3499	4759	6346	7130
8	Ash 3-28%	28	3253	4289	6011	6620
9	Ash 3-36%	36	3306	4468	6111	6940

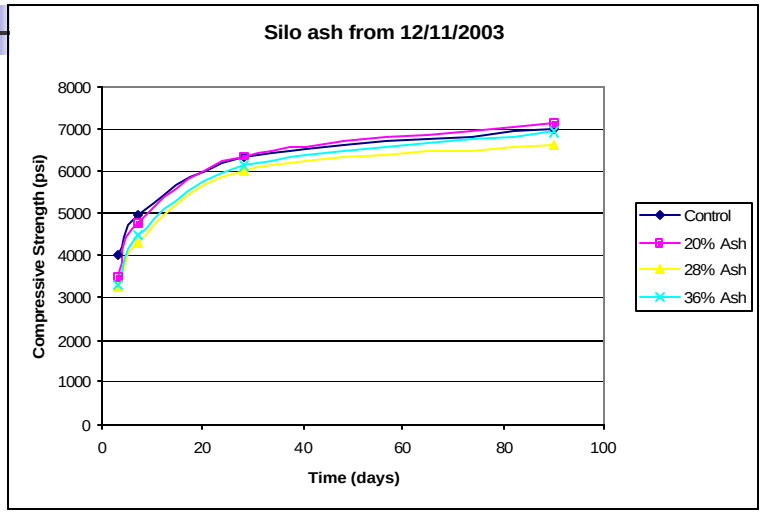
Concrete test results – ASH1



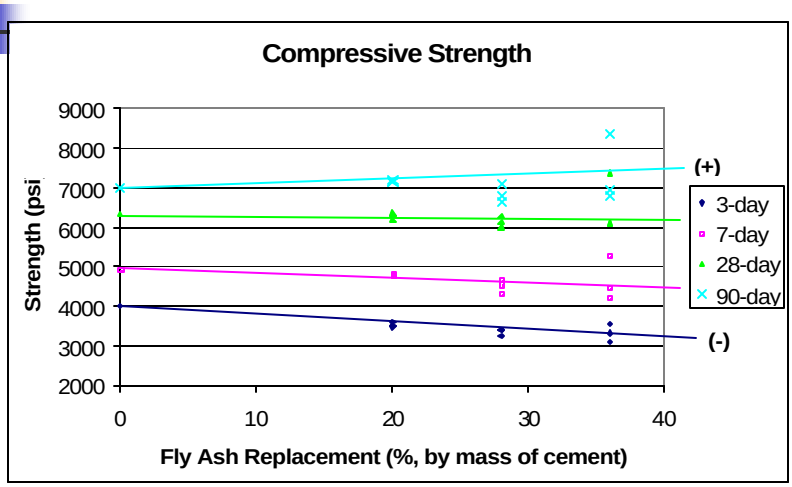
Concrete test results – ASH2



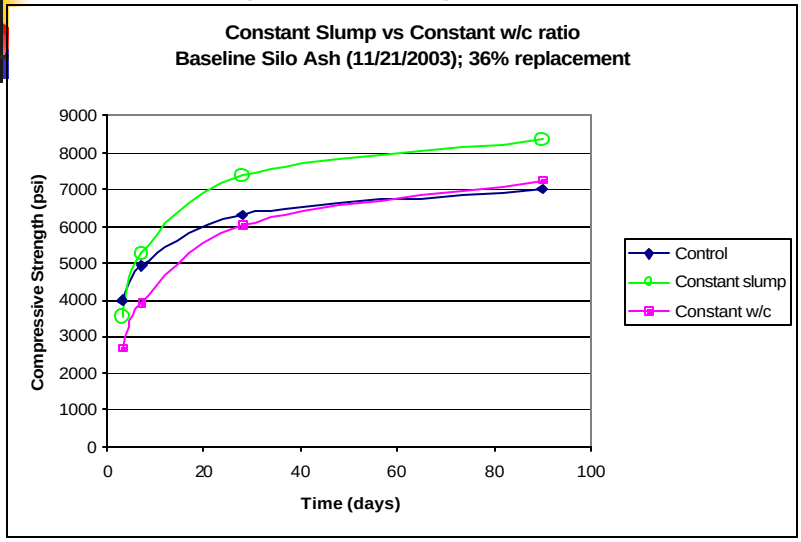
Concrete test results –ASH3



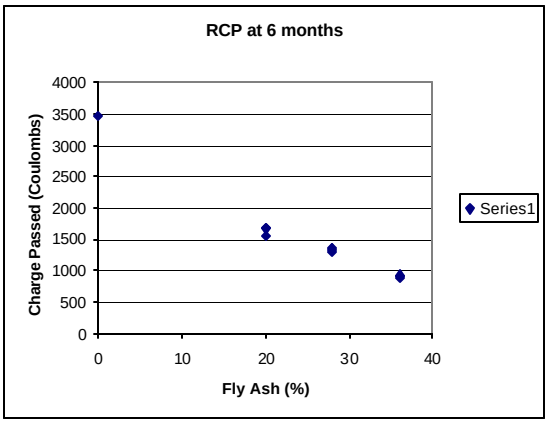
Summary: Compressive Strength Tests (4” by 8” cylinders)



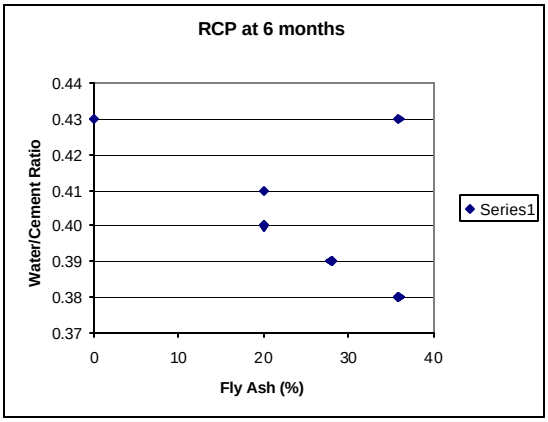
Summary: Strength Tests



Rapid Chloride Permeability



W/C ratio vs Fly Ash Replacement



Summary – Concrete Work

- The co-combustion fly ash produced concrete mixtures that were as workable as the baseline ash or the control mix
- All of the fly ash samples tended to reduce the amount of water needed to produce a concrete mixture of a specified slump
- All of the fly ash samples tended to increase the dosage of air-entraining solution needed to provide 6% air in the concrete

Summary – Concrete Work

- Compressive strength tests indicated that the co-combustion fly ash performed as good as the baseline fly ash from OGS
- Fly ash tended to lower the early strength gain (3 and 7 days) but enhance the long-term strength (90 days) of the concrete (relative to the control mixture)
- Existing mix design strategies can easily compensate for this early-age strength reduction

Summary – Concrete Work

- RCP tests exhibited decreasing permeability with increasing ash replacement –co-combustion ash performed the same as base-line ash
- Fly ash tended to reduce the RCP values by about a factor of 2 (relative to the control mix) when used at 20% replacement

Research Needs

- Fly ash uniformity testing still needs to be verified; however, preliminary work on ash from the autosampler indicated that it should not be a significant problem if OGS can maintain a uniform burn rate

Any Questions???