COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Waste to Energy Ash and Portland Cement Summer Research

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Background

The production of Portland Cement Concrete(PCC) for building material accounts for 7.4% of CO2 emissions and about 20 million tons of fly ash waste. Class C fly ash consist of calcium, alumina, and silica, provides early reaction results while being used during construction projects, maximum loss of ignition is 6%, has a lower bulk specific gravity than portland cement which means that the fine aggregate fraction of the concrete might need to be changed when conducting experiments. Fly ash is most commonly used as a pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds.Coal bottom ash contains a low amount of clickers, contributes to sustainable cement production, requires more water than fly ash due to the higher surface area, carbon in material absorbs more water than fly ash and the loss of ignition is 1.8%. This experiment explores the alternative uses for fly ash and bottom ash to be used in the production of bricks instead of being discarded in landfill.

Method-

Step 1: Finding the bulk density of Portland cement, Sand, Class C fly and bottom ash
Step 2: Computing a mixing formula for cement mortar and the TAM calorimetry
Step 3: Mixing Class C fly ash cement for 0%, 10%, 25% and 50% to put into the brick molds and rest for a day until removed and submerged in water
Step 4: Calculating 7 day compression test
Step 5: Calculating Load area, Max load, Compressive strength(MPA), and Elastic modulus(MPA)
Step 6: Calculating flow rate and making graph using Max Load(N) vs. Displacement (mm)
Step 7: Mixing Portland cement with Sand, Class C fly ash, Class C bottom ash and water for TAM calorimetry
Step 8: placing about 5 grams of cement from each trial inside a glass container and lowering them inside the TAM calorimetry machine
Step 9: Waiting 3 days for excel results from machine
Step 10: Grinding and seving bottom ash through a tray to receive less than 2mm bottom ash
Step 11: Calculating bulk density of the new Class C bottom ash
Step 12: Viewing excel documents received from machine

Class C Bottom/Fly Ash Mixing charts:

0%	volume (cm3)	mass (g)
OPC	460	636
Coal FA	-	-
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
10%	volume (cm3)	mass (g)
OPC	414	573
Coal FA	46	61
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
FA 25vol%	volume (cm3)	mass (g)
OPC	345	477
Coal FA	115	152
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
FA 50vol%	volume (cm3)	mass (g)
OPC	230	318
Coal FA	230	304
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
FA 75vol%	volume (cm3)	mass (g)
OPC	115	159
Coal FA	345	456
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
FA 100vol%	volume (cm3)	mass (g)
OPC	-	-
Coal FA	460	608
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4

0%	volume (cm3)	mass (g)
OPC	8	11.1
Coal FA	-	- .0
sand		
water	4	4.0
sand:binder=		-
water:binder=	0.5	0.4
total mass		15.1
10%	volume (cm3)	mass (g)
OPC	7	10.0
Coal FA	1	1.1
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.4
		15.0
FA 25vol%	volume (cm3)	mass (g)
OPC	6	8.3
Coal FA	2	2.6
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.4
		14.9
FA 50vol%	volume (cm3)	mass (g)
OPC	4	5.5
Coal FA	4	5.3
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.4
		14.8
FA 75vol%	volume (cm3)	mass (g)
OPC	2	2.8
Coal FA	6	7.9
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.4
		14.7
FA 100vol%	volume (cm3)	mass (g)
OPC	-	- .0
Coal FA	8	10.6
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.4

0%	volume (cm3)	mass (g)
OPC	460	636
Coal BA	-	-
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
10%	volume (cm3)	mass (g)
OPC	414	573
Coal BA	46	73
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.4
FA 25vol%	volume (cm3)	mass (g)
OPC	345	477
Coal BA	115	181
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.3
FA 50vol%	volume (cm3)	mass (g)
OPC	230	318
Coal BA	230	363
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.3
FA 75vol%	volume (cm3)	mass (g)
OPC	115	159
Coal BA	345	544
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.3
FA 100vol%	volume (cm3)	mass (g)
OPC	-	-
Coal BA	460	726
sand	690	1,095
water	230	230
sand:binder=	1.5	2
water:binder=	0.5	0.3

0%	volume (cm3)	mass (g)
OPC	8	11.1
Coal BA	-	- .0
sand		
water	4	4.0
sand:binder=		-
water:binder=	0.5	0.4
total mass		15.1
10%	volume (cm3)	mass (g)
OPC	7	10.0
Coal BA	1	1.3
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.36
		15.2
FA 25vol%	volume (cm3)	mass (g)
OPC	6	8.3
Coal BA	2	3.2
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.35
		15.5
FA 50vol%	volume (cm3)	mass (g)
OPC	4	5.5
Coal BA	4	6.3
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.34
		15.8
FA 75vol%	volume (cm3)	mass (g)
OPC	2	2.8
Coal BA	6	9.5
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.33
		16.2
FA 100vol%	volume (cm3)	mass (g)
OPC	-	- .0
Coal BA	8	12.6
sand		
water	4	4.0
sand:binder=		
water:binder=	0.5	0.3

Figure 1. Calculated mixing charts

Bottom/FLY Ash Derived Cement Mortar and Concrete – Mixture Formula

Water/Cement = 0.5

Water Addition: Consider BA/FA water reduction

Cement Mortar

Cement + Water + Fine Aggregate (Sand + BA/FA)
Fine fraction BA/FA replaces sand in percentage:
0%, 10%, 25%, 50%, 75%, 100%

Cement Mortar and Concrete – Processing and Testing steps

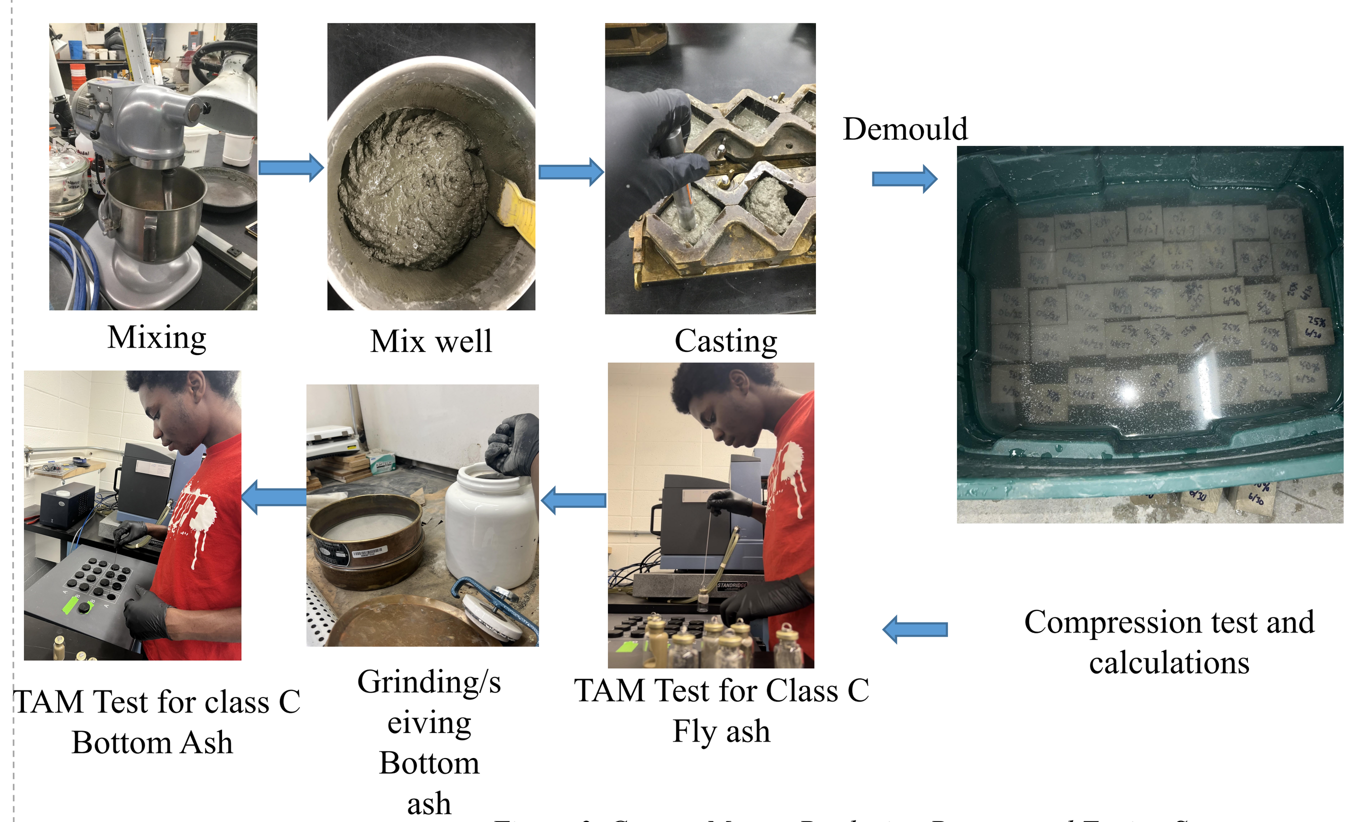


Figure 3. Cement Mortar Producing Process and Testing Steps

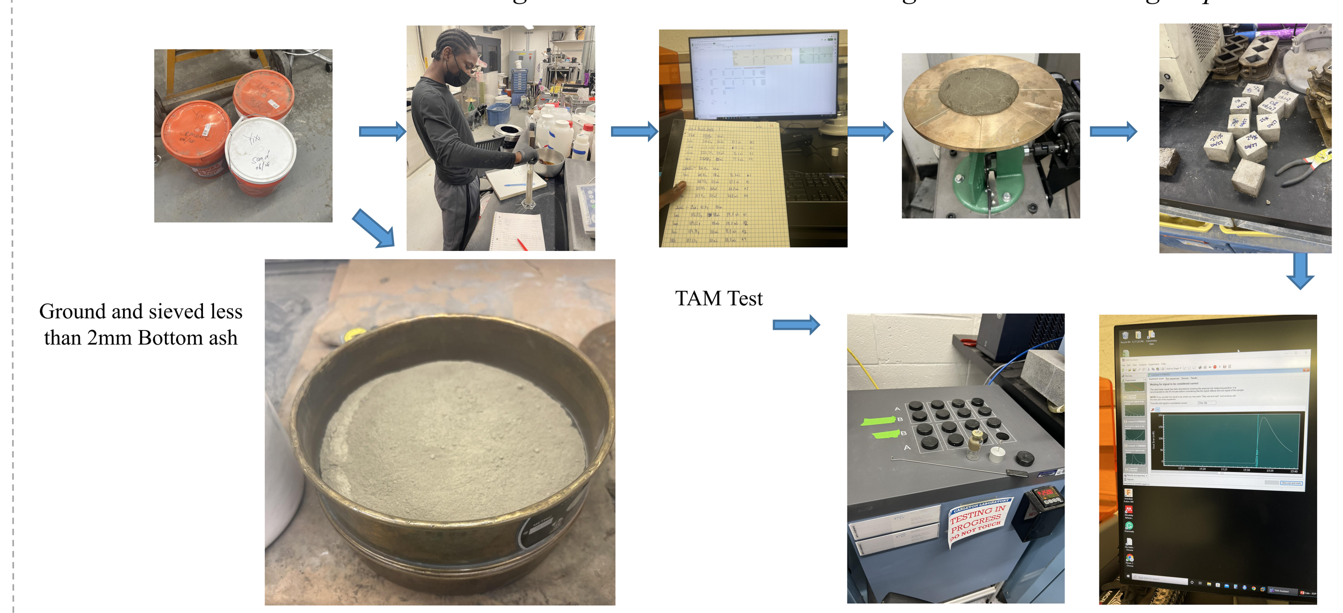


Figure 4. Equations

Flow(%)=average of scribed diameter(mm)-100(mm)/100(mm) x 100

Sample mass= Sample mass before tapped- Mass of flask used

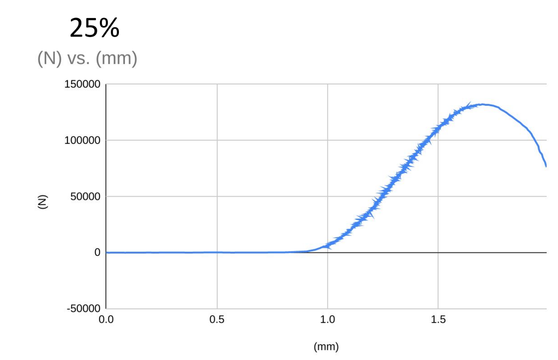
Loose Bulk Density= Sample mass/Loose volume

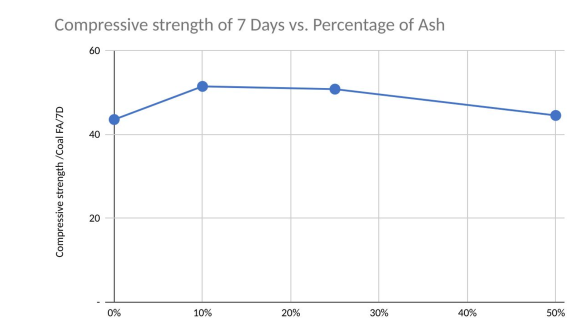
Packed Bulk Density= Sample mass/Tapped volume

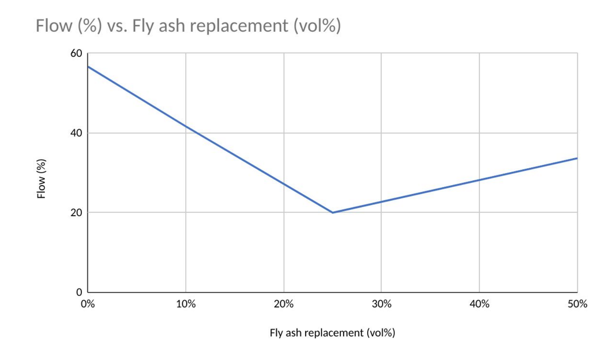
Load Area(mm2)= Length x Width

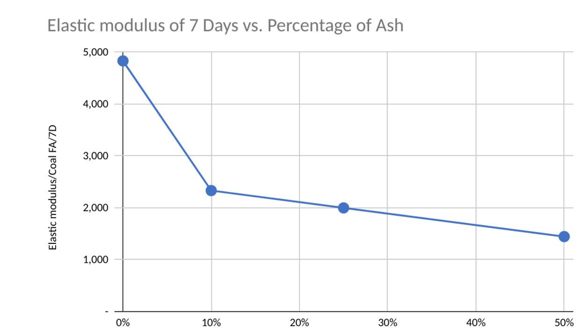
Compressive Strength= Max Load/ Load Area

Graphs

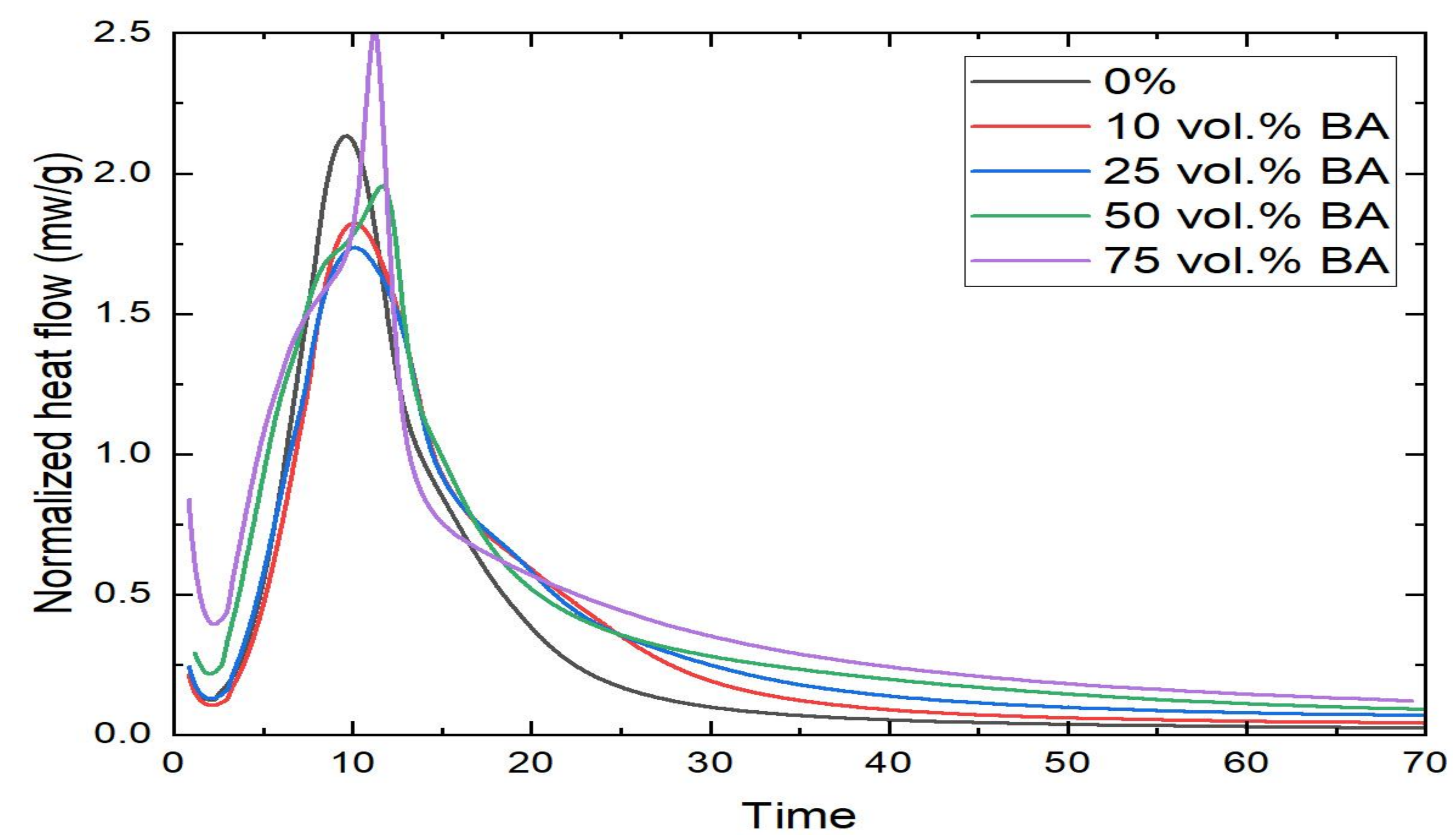








Class C Bottom Ash TAM results



Future Work/Conclusion

In conclusion this summer I have received results for the bottom ash in the TAM machine and all that is left to do is to run the same test with fly ash. Now that I have completed my summer internship at Columbia I won't be able to continue my research in Professor Thanos's lab but I have high hopes for the research being conducted.

Acknowledgments

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