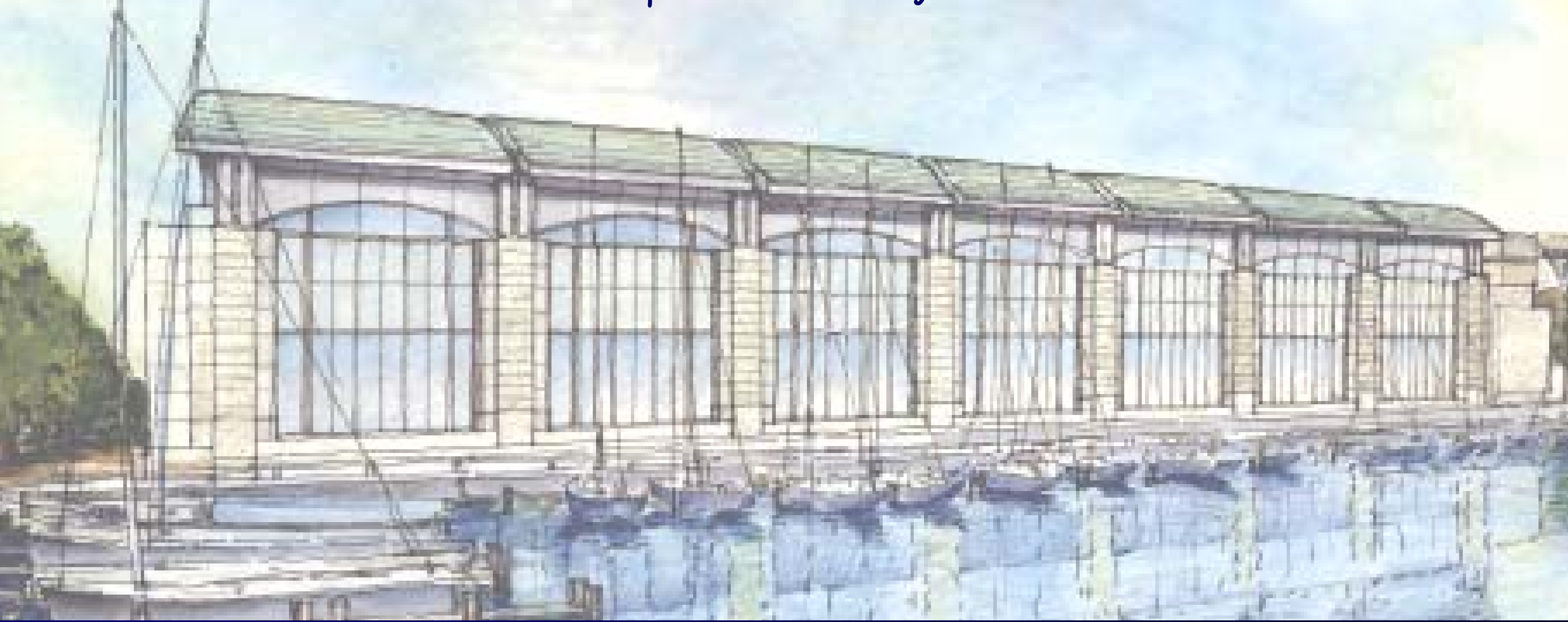
Wesley A. Brown Field House

Annapolis, Maryland



Peter Schneck
Construction Management
Dr. Riley
October 17, 2007

Project Overview

Analysis 1 – Fabric Mechanical Distribution Comparison

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Analysis 3 – Properties of Concrete Products with Fly Ash

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Presentation Outline

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Project Overview

Location:

- United State Naval Academy
- Annapolis, Maryland

Project Cost:

- $45 million

Size:

- 140,000 Sq. Ft.
- 2 Levels

Duration:

- 26 months
- February 2006 – March 2008

Building Function:

- Collegiate multi-sport complex
- Support for collegiate athletics and events

Project Delivery Method

- Design-Build

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Project Overview

Project Team – Organizational Chart

Owner:

Naval Facilities Engineering Command / The United States Naval Academy

Guaranteed Maximum Price

Construction Manager

Hensel Phelps Construction Company

Lump Sum

Architect of Record:	Mechanical Engineer:	Electrical Engineer:	Structural Engineer:	Fire Protection:	Associate Architect
HKS Inc.	Kavocs Whitney & Associates	M.C. Dean	Thorton Tomasetti	National Fire Protection	Shalom Baranes Associates

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Project Overview

Site Layout

- **Tight Space –**

  Neighboring building

- **One-way Streets –**

  Difficult for deliveries

- **Naval Academy's Campus –**

  Security: workers and deliveries

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Analysis 1:

Fabric Mechanical Distribution Comparison

Problem:

The current mechanical distribution system design in the Wesley A. Brown Field House has G90 double-walled pre-insulated ductwork in the athletic field area. This ductwork is to be installed at heights over 40'. The diameter of the ductwork is up to 58". This ductwork is expensive, difficult to install, and requires precious space on the project for lay-down

Goal:

To find an alternative ductwork system that addresses cost, schedule, and space issues on the Wesley A. Brown Field. The system needs to satisfy the Naval Academies require for a mechanical system in a state-of-the-art athletic facility.

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Analysis 1:
Fabric Mechanical Distribution Comparison

A fabric ductwork system from Ductsox Fabric Air Dispersion Products was investigated as an alternative to the Steel Ductwork.

Using the Ductsox Fabric Air Dispersion Design Guide, a Ductsox System for the Wesley A. Brown Field House using the following steps of design.

1. Shape
2. Design Layout
3. Fabric
4. Air Dispersion
5. Suspension

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Analysis 1:

Fabric Mechanical Distribution Comparison

1. Shape – The shape is cylindrical fabric duct, due to the exposed application. This shape also allows for any of the fabrics to be chosen
2. Design layout – The design layout was one that closely resembles Wesley A. Brown's current Mechanical Layout. The two 42,000 cfm Air Handler Units distribute air down four 190 foot runs of fabric duct at 21,000 cfm. The maximum velocity for a Ductsox system with inlet fittings is 1,400 fpm, however reducing the velocity to 1,200 fpm reduces and stress and noise. Using the design chart the diameter of fabric cylinders is determined to be 58" using 1,200 fpm as the inlet pressure.

Diameter	Inlet Velocity			
	1,000	1,200	1,400	1,600
50	13,635	16,362	19,090	21,817
52	14,748	17,698	20,647	23,597
54	15,904	19,085	22,266	25,447
56	17,104	20,525	23,946	27,367
58	18,348	22,017	25,687	29,356
60	19,635	23,562	27,489	31,416

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Analysis 1:
Fabric Mechanical Distribution Comparison

3. Fabric – Sedona-Xm a porous fabric was selected to replaced the double walled steel. The porous fabric does not allow of condensation to form in the ductwork, by creating a layer of protective tempered air.

Temperature Gradient For Impermeable fabrics | Temperature Gradient For Permeable Fabrics

4. Air Dispersion – The Air Dispersion was calculated by using the orifice chart in conjuction with the required throw distance. Using the formula:

(Height – 6) x 1.00 = Required Throw

For required throw at a height of 40', it was determined that 34' of required throw was needed. Using the orifice chart 3" holes every 9" on center are required.

5. Suspension System – Lastly a two row suspended H-track system was chosen to support the 58" diameter and for its ability to vary in attachment height

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Analysis 1:
Fabric Mechanical Distribution Comparison

Cost and Construction Analysis

Mechanical Ductwork Comparison				
	LNFT	AVG $/LNFT	COST ($)	DAYS
Ductsox	760	40	30400	14
Galvanized Steel	966	46.76	45171	66

- The fabric ductsox system saves both time and money.
- Fabric ductwork does not require as much lay down area as steel ductwork
- The fabric is lighter than steel, and can be installed safely by a two man crew
- Maintenance is faster and cheaper than the Steel Ductwork

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Analysis 1:
Fabric Mechanical Distribution Comparison

Conclusion:

The fabric ductwork system is cheaper, faster, and safer to install. The Naval Academy wants a state-of-art athletic facility, and the fabric ductwork system would provide the Academy with the performance needed. However, the material would not be steel. Although the fabric can be purchased in custom colors, the Naval Academy is still receiving a material that does not match the exposed steel structure. The aesthetics in the Wesley A. Brown Field House are important, but the amount of money and time saved using a fabric duct supports its use.

Wesley A. Brown Field House

Annapolis, Maryland

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Analysis 2:

Waterproofing Options for the Wesley A. Brown Field House

Problem:

The Wesley A. Brown Field House is located near the Santee Basin. Pits in the field house require waterproofing to protect specialized equipment that are stored in them. Waterproofing can be costly and time consuming, and not all types of waterproofing lend themselves to all applications. A Bituminous Asphalt with fiber system was specified for the project.

Goal:

To research different waterproofing systems to find one that better applies to Wesley A. Brown Field House requirements than the specified system.

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Analysis 2:

Waterproofing Options for the Wesley A. Brown Field House

The alternative waterproofing systems investigated:

Elastomeric Bituminous Modified Polyethleyene Fluid

Bentonite

	Advantages	Disadvantages
Asphalt w/ Fiber	• Easy to install • Adaptable to complex shapes • Good w/ Penetrations	• Temperature Sensitive • Vertical Surfaces • Defective Flashing • Needs 24hrs btw coats
Elastomeric Bituminous Modified Polyethleyene Fluid	• Resists acid soils • Easy joint seaming • Resilience and self-healing	• Unsuitable for blindside application • Temperature Sensitive • Poor ultra-violet radiation
Bentonite	• Easy installation • No VOC restrictions • Extreme Temperatures	• Needs constant hydrostatic pressure • Vapor Mitigation • Repair and replacement

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Analysis 2:

Waterproofing Options for the Wesley A. Brown Field House

A cost and schedule comparison revealed these results

Waterproofing Type	SQFT	Labor hours	Manhours	$/SQFT	Cost
Bituminous Asphalt with Fiber	23143	0.02	462.86	0.91	21060
Elastomeric Bituminous Modied Polyethleyene Fluid	23143	0.024	555.43	1.4	32400
Bentonite	23143	0.013	300.86	1.41	32632

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Analysis 2:

Waterproofing Options for the Wesley A. Brown Field House

Conclusion:

The specified Bituminous Asphalt with fibers proved to be the best material the Wesley A. Brown Field House.

Bituminous Asphalt – Slower than the Bentonite and temperature sensitive. Pits are poured in March, April, and May so temperature is not a concern

Elastomeric – both the slowest and most costly. This waterproofing system could be used, but the Bituminous Asphalt meets the requirements.

Bentonite – The fastest application. Important on a fast schedule, but it allows water mitigation. The Wesley A. Brown Field House is humidity sensitive containing wooden basketball courts. This could effect the mechanical loads.

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Analysis 3:
Properties of Concrete Products with Fly Ash

Problem:

The United States Naval Academy's Request for Proposal allows for the concrete used in the Wesley A. Brown Field House to include up to 25% fly ash in the cementitious material. Currently the mix design does not have fly ash.

Goal:

To investigate the properties of concrete with fly ash aggregate to determine if these mixes could be used on the Wesley A. Brown Field House project.

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Analysis 3:
Properties of Concrete Products with Fly Ash

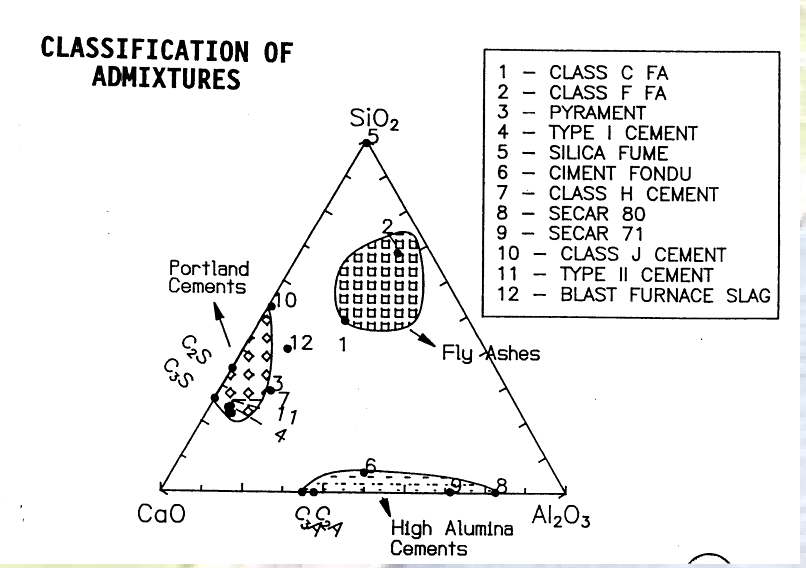
Fly Ash –

Fly ash is a coal combustion product

Pozzolanic material

Glassy spheres high in Silica, Alumina, and Calcium

Reacts with lime and calcium hydroxide to form Calcium Silicate Hyrdrate (CSH)



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Analysis 3:
Properties of Concrete Products with Fly Ash

In a normal Portland Cement mix, up to ¼ lb of lime can be produced for every 1 lb of Portland Cement used.

Lime is drawn out over time through capillaries in concrete causing efflorescence in Portland Cement mixes

Fly Ash reacts with the lime over time creating more CSH paste and filling capillaries in concrete

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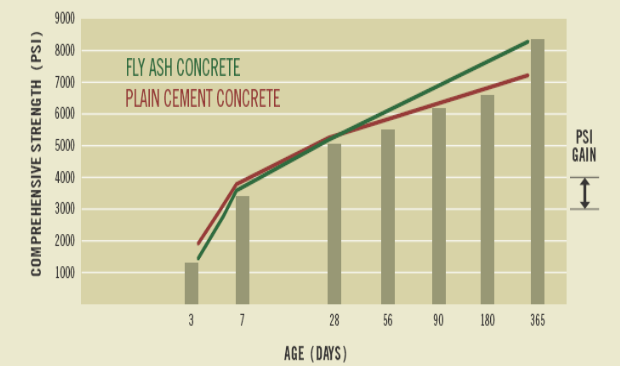
Analysis 3:
Properties of Concrete Products with Fly Ash

Result of reactions:

Strength:

When compared with a Portland Cement mix, Fly Ash concretes typically have less strength at 7 days, equal at 28 days, and more after a year



From Headwaters Resources Fly Ash for Concrete Brochure

Durability:

Concrete with Fly Ash has more durability than Portland Cement mixes. The reaction between the Fly Ash and lime seals capillaries that cause cracks and chemical wear on concrete

Workability

Due to the spherical shape of fly ash, it creates a "ball-bearing" effect, which increases the workability of the concrete

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Analysis 3:
Properties of Concrete Products with Fly Ash

Conclusion:

A concrete mixture that incorporates Fly Ash should be utilized. Fly Ash is a cheap recycled product that can be used effectively as a partial substitute for Portland Cement in concrete. The mix could potentially increase the strength, durability, and workability of the concrete while decreasing cost. The source and properties of the Fly Ash should be known and remain constant throughout the project.

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Analysis 4:
Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

Penn State's Coal Fired Power Plant

- Located at Southwest edge of the University Campus
- 4 Stoker Stoves produce power that is consumed by the University
- Produces two Solid Coal Combustion Products
  1. Fly Ash
  2. Bottom Ash

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Analysis 4:

Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

Problem:

Penn State is currently producing 600 to 800 tons of Fly Ash each year. The power plant is also producing 6,000 to 8,000 tons of bottom ash each year. Penn State is paying close to $35/ton to dispose of these materials in regulated landfills.

Goal:

To investigate the Coal Combustion Products that are produced at Penn State, and to find possible uses for them in the construction industry

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Analysis 4:

Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

- The use of Coal Combustion Products is regulated by Pennsylvania Law
- There are only 11 acceptable uses for Coal Combustion Products in Pennsylvania. The ones looked at for this analysis include:
  1. In the manufacture of concrete
  2. Structural Fill
  3. Drainage material and pipe bedding

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Analysis 4:

Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

1. In the manufacture of concrete

Fly Ash-

Penn State's Fly Ash was looked at in the application of the manufacture of concrete.

More specifically it was investigated as an application in the mix for Autoclaved Aerated Concrete (AAC) Blocks

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Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

Mixes containing varying amounts of the following material were poured and tested for strength at the Penn State Materials Research Laboratory

- Penn State Fly Ash
- Water
- Lime
- Portland Cement
- Aluminum
- Anhydrate

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Analysis 4:

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(6) 4 in blocks of each of the 6 different mixes were tested and averaged for strengths. The test had these results:

PSU fly ash ongoing test												
Nominal 4 in cube testing:			10.16	cm								
Sample	Number	Mass (both if app)		H2O mass	% mass	Density	g/cm3	Load	PSI	Mpa	ave load	ave density
		Room	Dry	lost	lost	Room	Dry	lbs				
A51	1	690.90	558.00	132.90	0.19	0.65677	0.532051	7120	445	3.068164	392.9167	0.5295717
	2	686.00	554.80	131.20	0.19	0.654098	0.529	6500	406.25	2.800992		
	3	645.80	553.40	92.40	0.14	0.615768	0.527665	5240	327.5	2.258031		
	4	639.20				0.609475	0.609475	5900	368.75	2.542439	322.5	0.6008932
	5	661.00				0.630261	0.630261	5540	346.25	2.387307		
	6	590.40				0.562944	0.562944	4040	252.5	1.740924		
A52	1	638.30	549.50	88.80	0.14	0.608616	0.523946	6580	411.25	2.835466	401.25	0.5284593
	2	673.40	554.00	119.40	0.18	0.642084	0.528237	7160	447.5	3.085401		
	3	662.20	559.20	103.00	0.16	0.631405	0.533195	5520	345	2.378689		
	4	627.00				0.597842	0.597842	6100	381.25	2.628623	362.0833	0.5925978
	5	598.90				0.571049	0.571049	5520	345	2.378689		
	6	638.60				0.608903	0.608903	5760	360	2.48211		
A71	1	617.70	494.80	122.90	0.20	0.588974	0.47179	5440	340	2.344215	319.5833	0.4639076
	2	613.70	464.00	149.70	0.24	0.58516	0.442422	5700	356.25	2.456255		
	3	618.70	500.80	117.90	0.19	0.589928	0.477511	4200	262.5	1.809872		
	4	578.90				0.551979	0.551979	4580	286.25	1.973622	257.5	0.5484191
	5	568.30				0.541872	0.541872	3580	223.75	1.5427		
	6	578.30				0.551407	0.551407	4200	262.5	1.809872		
A72	1	613.60	492.20	121.40	0.20	0.585065	0.469311	4200	262.5	1.809872	239.7917	0.4699464
	2	605.40	494.90	110.50	0.18	0.577246	0.471885	3090	193.125	1.331549		
	3	618.70	491.50	127.20	0.21	0.589928	0.468643	4220	263.75	1.81849		
	4	578.40				0.551502	0.551502	3240	202.5	1.396187	254.5833	0.5476881
	5	565.70				0.539393	0.539393	4340	271.25	1.870201		
	6	579.10				0.55217	0.55217	4640	290	1.999478		
A91	1	623.80	471.40	152.40	0.24	0.594791	0.449478	4720	295	2.033951	292.9167	0.4524656
	2	630.80	480.00	150.80	0.24	0.601465	0.457678	5000	312.5	2.154609		
	3	632.70	472.20	160.50	0.25	0.603277	0.450241	4340	271.25	1.870201		
	4	565.70				0.539393	0.539393	4100	256.25	1.76678	254.5833	0.5426981
	5	568.50				0.542062	0.542062	4080	255	1.758161		
	6	573.30				0.546639	0.546639	4040	252.5	1.740924		
A92	1	618.40	455.60	162.80	0.26	0.589642	0.434413	4480	280	1.93053	280	0.4365423
	2	615.90	462.80	153.10	0.25	0.587258	0.441278	4400	275	1.896056		
	3	615.70	455.10	160.60	0.26	0.587067	0.433936	4560	285	1.965004		
	4	586.70				0.559416	0.559416	3320	207.5	1.430661	217.5	0.5572866
	5	584.20				0.557032	0.557032	3380	211.25	1.456516		
	6	582.50				0.555411	0.555411	3740	233.75	1.611648		

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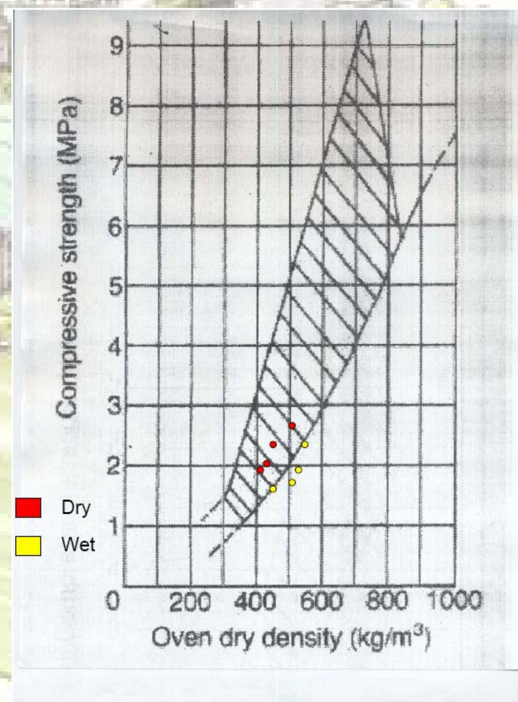
Analysis 3:

Penn State's Coal Fired Power Plant and uses for its Coal Combustion Products

Plotting the average strength on a graph used to indicate AAC acceptable industry Strengths vs. Oven Dry Density yielded this graph:



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Analysis 4:
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Results:

The Dry mixes feel in the acceptable region of the graph.

AAC produced from Penn State Fly Ash could possibly be used as a construction block

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Bottom Ash –

Penn State's Bottom Ash was investigated as a potential material for:

Structural Fill used in flowable fill

Drainage Material and Pipe Bedding

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Both the physical and chemical properties of Penn State's Bottom Ash are not acceptable for Structural Fill or as a Pipe bedding material.

The gradation has fines and material that is too large for use as flowable fill.

Bulk Density 22.48 lbs. per cubic foot

Screen Test	%	Cumulative % Down	Cumulative % Up
+ 1/2"SQ	7.64	7.64	100.00
1/2"SQ X 1/4"SQ	73.40	81.03	92.36
1/4"SQ X 8M	17.00	98.03	18.97
8M X 0	1.97	100.00	1.97
	100.00 %		

MOISTURE AS RECEIVED 2.93%

CARBON AS RECEIVED 54.55% DRY BASIS 56.20%

LOSS ON IGNITION 65.03%

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Conclusion:

Penn State's Coal Combustion Products are not being recycled and are costing Penn State money to dispose of them.

Fly Ash

Penn State's Fly Ash can be used in AAC that can be used as a replacement for CMU block in some applications. AAC blocks have great thermal resistance and resist sound transmission as well. With thermal and sound tests, Penn State might be able to produce AAC blocks to use here on campus and other projects.

Bottom Ash

Although Penn State's Bottom Ash is not a suitable material for structural fill or pipe bedding as is, a screening or grinding process could produce a desirable material for these applications. A feasibility study should be done to see if these processes could help alleviate some of the problem at the Coal Fired Power Plant

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Questions

Acknowledgements

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Wesley A. Brown Field House

Annapolis, Maryland

Project Overview

Analysis 1 – Fabric Mechanical Distribution Comparison

Analysis 2 – Waterproofing Options for the Wesley A. Brown Field House

Analysis 3 – Properties of Concrete Products with Fly Ash

Analysis 4 – Penn State's Coal Fired Power Plant and Uses for its Coal Combustion Products

Acknowledgements

Questions

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