The Use of Power Plant Combustion Products in Maryland

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ABSTRACT

Maryland power plants produce about 1.5 million tons of combustion products per year. Currently about half of this production is put to constructive use in highway, mine, and construction applications. Five years ago the Maryland Power Plant Research Program initiated a series of demonstration projects to develop beneficial use of all of Maryland's projected annual production of 2 million tons of combustion products per year. The focus of Maryland's program is to demonstrate that a mixture of combustion products or combustion products and high lime content waste products can replace concrete as the cementitious material in most standard geotechnical applications and by improving the economics of such projects make more environmentally beneficial projects feasible. A demonstration of bulk filling a mine has been completed and is providing valuable data on the environmental performance of a mixture of fluid bed combustion products, fly ash, and flue gas desulfurization material used as cementitious material in an acid mine environment. Demonstration projects in seepage grouting, intrusion grouting, and covering a high sulfur mine pavement are underway. Maryland's 450 abandoned coal mines, numerous disposal areas, brown-field sites, and karst topographic belt are being studied to identify opportunities to demonstrate the use of combustion products in paste applications, tremie seals, diaphragm walls, secant drilled shaft walls, slurry trenches, solidification and stabilization of dredge fill, compaction grouting, jet grouting, in-situ deep mixing, and in impermeable caps and other soil cement applications.

INTRODUCTION

The Maryland Department of Natural Resources Power Plant Research Program is a non-regulatory program that ensures the Maryland's utilities meet the State's electricity demands at reasonable cost while protecting the state's environment and valuable natural resources. The Program conducts research on power plant issues and the impact of power plants on the environment. Our recommendations generally take the form of testimony before the Maryland Public Service Commission recommending the conditions that should be placed on construction of new power plants or major modifications of existing power plants. Among the important power plant issues is what to do with combustion products. Historically, like most of the industry, Maryland power plant combustion products were generally relegated to being waste products and disposed in the cheapest and most convenient manner possible.

CURRENT ESTABLISHED USES

In the most recent decade Maryland has had modest success in beneficial use of power plant combustion products. About half of our current annual production of 1.5 million tons of combustion products is put to constructive use in the cement industry or directly in highway, mine, and construction applications. Current applications that seem firmly established and likely to remain as part of our industry infrastructure include:

- Use of most of the annual production of bottom ash as road grit for winter application.
- Use of nearly 50,000 tons per year of fly ash by two companies supplying flowable fill to the construction industry.
- Use of all the 300,000 tons per year of fluid bed combustion products produced at Warrior Run by our coal mine operators in mine land reclamation.
- Processing 100,000 tons per year of fly ash to reduce the unburned carbon content of the ash to less than 3 percent for sale to the cement industry. This joint venture of Baltimore Gas and Electric and Separation Technologies, Inc. came on line in 1999 and can be expanded as the market for its product expands.

PROJECTED PRODUCTION AND USE GOALS

Projected power plant construction activity in Maryland is expected to increase the amount of power plant combustion products produced each year to over 2 million tons. The Maryland Power Plant Research Program has a lofty goal to make practical the recommendation to the Public Service Commission that all new power plants not have ash piles and that new ash piles not be approved for existing power plants. To that end we are monitoring certain massive beneficial applications of power plant combustion products to ensure such uses are environmentally acceptable and promoting innovative uses that are environmentally beneficial.

USES BEING MONITORED

Among the projects being monitored are major structural fills laid down by ordinary construction methods for highway embankments and industrial and commercial office parks. The monitoring of these structural fills has been the subject of detailed reporting by William Hodges[1] of our office and our supporting contractors[2]. Their reports provide details that are important to those considering such applications. In general, four trends regarding the fate and transport of inorganic constituents derived from fly ash are evident in the structural fills we are monitoring:

1. Concentrations of cations and anions in the pore water decrease as leachate migrates vertically through the embankment, indicating that calcium, sodium, magnesium, potassium, sulfate and chloride are precipitating or adsorbing in the underlying filter material and native soil.
2. Concentrations of trace elements in the pore water, including arsenic and selenium, decrease as the leachate migrates vertically through the embankment. These trace elements are likely absorbing into ferric hydroxides under oxidizing conditions, or precipitating in the filter material, thus limiting their mobility.

3. Manganese and iron concentrations in pore water increase with depth in the unsaturated zone indicating that the leachate formed in the fly ash is mobilizing these constituents in the filter layer or native soil, possibly due to changing oxidation conditions. However, the iron and manganese concentrations in groundwater beneath the embankments are less than the pore water concentrations.
4. Concentrations of cations, anions and trace elements in groundwater under the embankments are substantially less than the concentrations in the pore water indicating that the leachate constituents are either attenuated in the water table aquifer or are being diluted with clean groundwater. Consequently, fly ash in the embankments has no discernible impact on local groundwater quality.

In most cases monitoring also shows significant effects on water quality due to the land application of fertilizer in rural areas and the application of deicing agents on highways. Our monitoring suggests that power plant combustion products from the coals burned in Maryland can be used in large structural fills but that the fills must be designed to provide the level of protection for groundwater that is appropriate to the site.

Another application of coal combustion products being carefully monitored is bulk filling of underground mines. In 1996 we injected 6500 yards of grout prepared from the 60 percent fluid bed combustion products, 20 percent fly ash, and 20 percent fluid gas de-sulfurization material into the Frazee Mine on Winding Ridge near Friendsville, Maryland. Six years of monitoring shows that we have reduced acid production in the mine in proportion to the amount of void space we filled. Most importantly, we have reduced concentrations of iron, aluminum, and sulfates in the effluent water to well below pre-injection levels. Metal concentrations (cobalt, zinc, copper, nickel, and manganese) all show favorable trends and some have dropped below detection limits in the most recent three years of monitoring. Calcium and sodium ions that were not previously present are now present in the effluent, but at harmless levels. Details regarding this project and the monitoring results are available in Reference 3..

PROMOTING INNOVATIVE USES

Monitoring of these projects has provided important guidance for projects we have underway or are planning to promote innovative uses of power plant combustion products. Our general strategy to increase the use of these products is to demonstrate their use as the cementitious material in standard geotechnical engineering applications where portland cement mixtures are normally used. From an environmental and volume point of view such applications related to reclamation of drastically disturbed lands are most important. Maryland has four categories of drastically disturbed lands:

- abandoned coal mines in Western Maryland,
- disposal sites,
- brown-field sites, and
- naturally disturbed lands (the karst belt of Central Maryland).

As is the case for many states, Maryland has had only limited success in dealing with drastically disturbed lands. Our Bureau of Mines has had some success in treating acid mine drainage with limestone dosers and passive treatment systems. The Bureau is also reclaiming abandoned surface mines and mine debris as rapidly as funds permit. Other state agencies, local governments, and industry are implementing some rather expensive solutions at disposal sites. Our counties and cities are only beginning to design solutions for brown-field sites. Our State Highway Administration and counties are faced with ever growing

problems as the Baltimore-Washington megaopolis expands into the Maryland karst belt. In addition to the damage to linear facilities and structures that is associated with karst formations, we have just begun to recognize the impact that karst formations have on groundwater quality and the impact these formations have on the storage of surface and ground water.

The perspective of the Maryland Power Plant Research Program is that most projects to restore drastically disturbed lands that require large volumes of cementitious material could benefit economically by substituting appropriate mixtures of locally generated power plant combustion products or mixtures of these products and high lime content waste products for the Portland cement mixtures normally used. A major infrastructure has develop around the manufacture and distribution of Portland cement for geotechnical engineering applications. A similar infrastructure based on the use of power plant combustion products or mixtures of these products and high lime content waste products is needed to take advantage of the potential economic benefits offered by massive use of these materials.

Our approach to implementing our core strategy for increased utilization of power plant combustion products is to sponsor and seek support and funding for demonstration projects that can stay in place to the benefit of the environment. These projects demonstrate both the technology of using power plant combustion products and the range of partnership support and funding available for such work. Specific projects that we have underway or at various stages of planning include:

- **Kempton Man Shaft Project -** The Office of Surface Mining has funded our proposal to install a seepage barrier of coal combustion products to a depth of 150 feet around the abandoned 400-foot man shaft to Kempton Mine 42. This 10 x 20- foot shaft was pumped at the rate of 100,000 gallons per day from the 178-foot level when the mine was in operation. The Maryland Bureau of Mines, using funding from the Environmental Protection Agency, has completed exploratory drilling around the shaft. The subsurface conditions found confirmed that the shaft is a good candidate for installation of a seepage barrier of coal combustion products from the nearby North Branch Power Plant in Bayard, West Virginia. Intrusion grouting to install the seepage barrier is planned for the 2002 construction season. Monitoring wells will remain in place to monitor performance of the seepage barrier for several years. While seepage barriers do not represent a massive use of combustion products, their collective use in cutoffs for mining applications, at disposal sites, and at brown-field sites would be a substantial beneficial use, especially to the extent we demonstrate a lowering of the cost of such cutoffs the concept may find broader application.
- **Siege of Acre Project -** The Department of Energy Combustion Byproducts Recycling Consortium awarded us a $50,000 subcontract through West Virginia University to cost share capping of an isolated segment of the exposed high sulfur pavement in Kempton Mine 42. The Siege of Acre segment of Mine 42 contains all of the exposed pavement in the Kempton Mine Complex that is in Maryland but is representative of several hundred acres of exposed high sulfur pavement in the overall complex, most of the exposed mine pavement is in the West Virginia portion of the Complex. The Complex now produces 3.5 million gallons a day of acid mine drainage with a pH of approximately 3 and has been doing so for 50 years. We will drill exploratory holes to investigate the movement water and acid production in this segment of the mine during the 2001 construction season and prepare for grouting the pavement cap in place during the 2002 construction season. This project will also use

coal combustion products available from the nearby North Branch Power Plant.

- **Ezra Michael Mine No. 3 -** This mine presents an excellent opportunity to study the bulk filling of sections of a mine to reduce acid production and manage any residual acid mine drainage. AES Warrior Run has agreed to provide fluid bed coal combustion products for the project. We and the Maryland Bureau of Mines have jointly submitted a pre-application to the Combustion Byproducts Recycling Consortium for cost sharing the project.
- **Kempton Borehole Project -** An access hole for running power lines into Kempton Mine 42 is now the lowest elevation discharge point for the Kempton Mine Complex into Laurel Run in Maryland. The Bureau of Mines will install flow control at the Borehole to stabilize flow at the nearby Airshaft where the mine discharge is used for a water powered lime kiln dust doser. We will have Hemmings Associates design a grout of North Branch coal combustion products to cement the large diameter pipe and valve in place. The access road to the Borehole runs through a sensitive area near the Laurel Run Wetlands and will be improved by surfacing with a pseudo soil cement mixture of North Branch coal combustion products and "dirty" sandstone donated by a local materials company, Fairfax Materials, Inc.
- **Karst Formation Projects -** We have entered into a Memorandum of Understanding with the Western Maryland Resource Conservation and Development Council, Inc. to demonstrate other geotechnical engineering applications of cementitious material prepared from coal combustion products. This effort has initially focused on engineering problems related to karst formations in Maryland. Their research reveals that the engineering problems unique to karst formations have received considerable attention in the Southern Illinois Sinkhole Plain, here in the Kentucky Blue Grass Region, and in our neighboring states. Demonstration projects will be defined to take advantage of the distribution and cementitious properties of mixtures of coal combustion products and high lime content waste products of the industries (cement and limestone) normally found in karst areas. In Maryland we are particularly concern about rural water quality where solution cavities provide direct routes from sources of contamination to groundwater, a growing problem as sources of contamination increase with urbanization of our rural areas. Also, as quarries grow deeper and expand, sinkholes in the surrounding area become a bigger community and local government issue.

As we look to the future and consider the depletion of construction materials, the growing need for structural fills, and the specific geotechnical engineering problems in our four categories of disturbed lands, we observed that the cheapest combination of environmentally acceptable material and transportation costs for massive projects may well be power plant combustion products. If not considered an environmentally acceptable material in the non-solidified form, certainly when set up into an impermeable monolith their environmental and mechanical properties make them an excellent substitute for most applications of cementitious material prepared with portland cement. Our analysis and experience suggest most coal combustion products could be used in lieu of sand or crushed stone in many pumped slurry fills. Mixed to take advantage of their cementitious properties, coal combustion products can substitute for expensive clays in slurry trenches and give structural strength not achieved with clays. Certainly, the cores we have pulled from Winding Ridge suggest mixtures of combustion products alone can substitute for Portland cement mixtures or concrete in secant drilled shaft walls, diaphragm walls, and tremie seals as well as substituting for the normal Portland cement grouts in intrusion, pressure, and compaction grouting.

Structural fills remain the most likely massive application of power plant combustion products. The Maryland Power Plant Research Program is working with URS, the engineering consultant to the Washington County Regional Airport, to determine if combustion products can form a part of the 2.5 million yards of fill required for their runway extension project. This will require meeting Federal Aviation Administration geotechnical specifications and rigid state and local environmental requirements. Combustion products and rail transport from several power plants will have to be used to meet the time schedule. If permitted, combustion products will have to be integrated with local fill materials and possibly dredge fill to meet the quantity and time demands of the project. This project provides an opportunity to create a part of the infrastructure we feel is necessary to make power plant combustion products a competitive construction material in Maryland.

A common requirement of all geotechnical engineering projects is that the site be carefully and thoroughly characterized. It was quickly apparent that the evolving capability of computer systems to store, access, and manipulate data for three-dimensional visualizations was of paramount importance in the study of abandoned mines. This led us early on to acquisition of hardware and software at Frostburg State University to create a Geographic Information System (GIS) that now supports all our investigations of drastically disturbed lands. The value of this system is daily demonstrated as detailed planning and engineering for demonstration projects continues. Operation of the GIS presents an ideal opportunity to integrate the wizardry of our academic and student communities with the judgment of experienced engineers.

While the lofty goal in all our studies and demonstration projects is to use power plant combustion products as they are produced, we look to the current work the Department of Energy is funding here at the Kentucky Center for Applied Energy Research and Western Kentucky Energy to recover fuel and other products from ash piles as a way of having our power plant operators mine away their legacy of ash piles.

SUMMARY

In summary, the scope of the Maryland Power Plant Research Program's activities relative to power plant combustion products include:

- Disseminating information on the availability, quantity, and properties of power plant combustion products;
- Studying of the potential environmental effects of power plant combustion products generated in Maryland and at nearby power plants that may find applications in Maryland;
- Field verifying the environmental performance of high volume uses of power plant combustion products as such uses are implemented in Maryland;
- Sponsoring of and seeking funding for projects to demonstrate the environmental, technical, and economic feasibility of innovative beneficial applications of power plant combustion products in Maryland;
- Pushing the envelope of geotechnical engineering applications of power plant combustion products in recognition that the special properties of power plant combustion products may offer advantages not available in conventional approaches to geotechnical engineering; and
- Promoting our balanced approach to power plant construction that includes careful examination as to whether the vendor's plans include optimum use of the combustion products over the lifetime of the proposed power plant.

REFERENCES

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