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TECHNICAL REPORT
March 1 through May 31, 1995

Project Title: **USE OF FLUIDIZED BED COMBUSTION BY-PRODUCTS FOR
LINERS AND ALKALI SUBSTITUTES**

DOE Cooperative Agreement Number: DE-FC22-92PC92521 (Year 3)
ICCI Project Number: 94-1/3.1B-5M
Principal Investigator: Bradley C. Paul, Southern Illinois University at
Carbondale
Other Investigators: Steve Esling, Southern Illinois University at
Carbondale; Mr. F. Pisani, Illinois Abandoned
Mined Lands Reclamation Council;
Mr. T. Wells, Archer Daniels Midland
Project Manager: Dr. Dan Banerjee, Illinois Clean Coal Institute

ABSTRACT

Fluidized Bed Combustion of coal eliminates most emissions of sulfur and nitrogen oxides, but produces sizable volumes of a solid residue that EPA may require to be placed in capped and lined landfills. Fluidized Bed Combustors are one of the most promising growth markets for Illinois coal and imposing cap and liner requirements may render the technology economically inviable. Fluidized Bed residues are cement-like and when mixed with soil produce a material as impermeable as the clay liners used at landfills. This project will demonstrate that Fluidized Bed Combustion Residues can be mixed with soils by regular construction equipment and used in place of clays as a liner material. The demonstration cap will cover an area of 7 acres, and will prevent water infiltration into acid producing material.

Baseline studies of Briar Creek indicate that the water is now highly degraded by acid drainage. Construction delays have enhanced the data collected on Briar Creek by allowing monitoring to continue through major seasonal changes without any effects attributable to the FBC ash. The materials needed to place the wells and lysimeters as soon as the weather improves this spring have been purchased and delivered. A contractor has been arranged to build and deliver a mobile foam generator and spray to the field to demonstrate fugitive dust control from FBC fly ash. The dust problem is one of the key technical barriers to more widespread use of FBC ash.

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EXECUTIVE SUMMARY

Fluidized Bed Combustion of coal eliminates most sulfur dioxide and nitrogen oxide emissions. It is considered a best available control technology, and is the favored technology for new steam and electric power generation amongst Non-Utility Generators. Non-Utility Generators are expected to be the major developers of the U.S. new electric generating capacity, and are a key growth market for the Illinois Coal Industry.

This new clean coal technology is at risk due to provisions of the Resource Conservation and Recovery Act (RCRA) because EPA has not yet made a determination that the solid residues from FBC combustion are non-hazardous. Cap and liner requirements if imposed on FBC combustion byproducts may make the technology not economically viable. Previous work by the investigators, has shown that FBC combustion byproducts, when mixed with soils and degraded mine rock, produce stabilized materials with permeabilities as low as the natural clay liners required for disposal of RCRA subtitle C and D wastes. This project will demonstrate that FBC byproducts can be used to make impermeable caps and liners by building a large cap over a 7 acre field site. The project will also demonstrate construction techniques using conventional earth moving machinery. Perhaps most importantly, this project will include demonstration of the use of foam from mobile spray bar systems for dust control. FBC ash dust has never been successfully controlled outside of fixed enclosed buildings, which are not feasible for construction sites typical of cap and liner placement. Unless dust control can be established, showing materials performance and construction placement techniques will probably not open markets.

OBJECTIVES

This project is a field scale demonstration. The objectives of this project are:

- 1- Demonstrate that Fluidized Bed Combustion (FBC) byproducts can be used to augment natural soils to produce liners for landfills and waste disposal facilities.
- 2- Demonstrate that FBC byproducts can be handled and mixed in the field on a large scale using readily available construction equipment.
- 3- Demonstrate that FBC byproducts can be used as a substitute for alkali chemicals in environmental management work.

To achieve these objectives a seven acre field site will be prepared. Ten thousand tons of FBC ash will be mixed with mine waste rock and soil to produce a low permeability cap similar to the liners used at landfills. In the construction phase, techniques for controlling fugitive dust, mixing the ash with soil on a commercial construction scale, and placing the mixture as a liner will be explored. Controlling fugitive dust is particularly crucial because in an open mobile construction setting there is little opportunity to handle the ash entirely in enclosed structures, and many landfill sites are close enough to urban areas that unrestricted dust release will not be accepted environmentally. In the post construction phase the liner will be monitored for structural integrity and effectiveness in blocking the percolation of water.

If the seepage barriers and liners are effective, there will be little wetting of the GOB, and acid mine drainage will not be produced. The site will be monitored for seepage using lysimeters, monitor wells, and water quality in Briar Creek. The integrity of the liner will be monitored visually and by surveying of monuments placed in the liner to indicate heave and movement.

INTRODUCTION AND BACKGROUND

Ash from the combustion of coal has been considered for regulation as a dangerous solid waste for over 10 years. During the review period, coal combustion ash was exempted from stringent regulations under the Resource Conservation and Recovery Act (RCRA) by the Bellville Amendment. In 1993, the EPA ruled that coal combustion ash from regular power plants was non-hazardous and exempted from RCRA regulation. No ruling has been made on FBC power plant ashes, which continue their uncertain future under the Bellville Amendment.

FBC power plants are a key market for the Illinois Coal Industry. There is no doubt that the Clean Air Act Amendments will cause a loss of market for Illinois Coal with conventional power plants that must face expensive scrubber retrofits or continuing SO₂ allowance purchases. Non-Utility Generators (NUGs) are not under the SO₂ cap and are required only to use the best available control technology to eliminate as much SO₂ emission as possible.

FBC is the most frequent control technology of choice amongst the NUGs. Non-Utility Generators are expected to build most of the new units needed to meet U.S. power needs. Archer Daniels Midland (ADM) (one of the cooperating organizations for this project) is projecting to double their production by just after the year 2000, and enough capacity addition to increase production by 50% has already been contracted. The existing boilers at ADM already are the equivalent of a 280 megawatt generating station, but coal consumption is far higher than needed for electricity alone, since the boilers also provide heat for grain processing.

If Illinois is to capture the new growth market for power and steam production, protecting and promoting FBC technology will be crucial. FBC power plants produce 250% of the solid byproducts of conventional pulverized coal units and RCRA regulations requiring disposal in lined and capped landfills at 7 times the price of conventional monofill disposal would render the technology economically infeasible. (FBC units directly fire limestone with coal to adsorb SO_2 as it is created and thus have a larger volume of non-combustible material). At the heart of the issue of whether FBC byproducts are environmentally hazardous are their high content of calcium oxides (created by exposing limestone to boiler temperatures). The portlandite formed in this way is responsible for the same high pH values seen during the curing of concrete. In previous laboratory and small scale field studies by the P.I., these reactions also allowed FBC fly ash to act as a soil stabilizer, just as cement does, and for FBC soil mixtures to achieve the same low permeabilities as clay liners used for landfills. In fact one of the problems in many percolation tests conducted by the P.I. in previous work has been that FBC byproducts are so impermeable that they produce no leachate to analyze. Thus, one of the prospects to be explored in this study is whether FBC byproducts can be used as a soil additive to substitute for clay in landfill liners.

For many low value bulk materials, the cost of transportation approaches or exceeds the value of the material itself. FBC ash can be used to amend natural soils and degraded rock material to produce a substance as impermeable as the clay liners used in landfills. The cap and seepage barrier at the Thunderbird site will be made from about 20% FBC ash and 80% on-site soil materials. This ratio would mean that companies planning to build impermeable liners would only have to haul in 20% of the liner material instead of 100% as is the case with clays. The ability of FBC ash to amend on-site soils would give it potentially significant market penetration advantages.

Demonstrating a bonafide potential use for FBC ash would aide in deregulating the material as a waste, and demonstrating that the material can be used to produce almost impermeable liners when used as an amendment to existing site soils would aid in market penetration. Still FBC ash would find barriers to use in terms of handling problems, particularly issues related to dust. Sites now receiving FBC ash for disposal must either dump ash in totally enclosed spray fogged buildings (not available at construction sites where liners are developed over large land areas), or have variances that allow for large scale fugitive dust release (not available in many of the near suburban areas where lined landfills are needed). Some FBC generators have had to resort to pelletization of the ash to reduce dusting to acceptable levels.

ADM is considering such a system, but the cost would be high, and the pelletized material probably would not be suitable for preparation of liners.

This demonstration is to show that dust problems can be managed, materials can be mixed and placed, and the liners created would be effective.

EXPERIMENTAL PROCEDURE

Because this project is a field demonstration, rather than a lab study, the experimental procedure is in many ways closer to a construction plan and sequence. The study begins with baseline water quality monitoring on Briar Creek prior to construction. Results from the baseline study show Briar Creek to be highly degraded by Acid Mine Drainage (AMD) at this time. Previous quarterly reports have included samples of typical data on water quality.

Several truck-loads of FBC byproducts are to be brought and stock-piled at the site. When these trucks are unloaded, there will be no dust control, but high volume samplers are to be in operation, to help establish a baseline for dust generation. When the pit is filled with GOB, construction will shift to the far east end where the lateral seepage barrier will be placed. During this time, lysimeters will be placed around the 7 acre cap site, with around 4 or more lysimeters in each subplot. The lysimeters will be buried to leave the site open for heavy construction equipment.

During the time that the lysimeters are being placed, construction work will be continuing on the lateral seepage barrier. The contractor has prepared a spray bar using conventional water sprays mounted on a bulldozer. The contractor will attempt to dump the trucks into a water curtained dozer blade. High volume samplers and video recording equipment will measure dust levels under these conditions and compare them to determine the level of dust control achieved. The contractor plan represents the simplest form of field mobile dust control technology. Some variations on the system will probably be attempted by the contractor in the event that the simple water curtain is inadequate.

As construction moves to the cap and liner zone over the buried lysimeters, experiments will begin with the use of microfoam as a dust suppression system. Details of the system are covered under progress this quarter. Again high volume air sampling will be used to determine the effectiveness of the system.

GOB and FBC byproducts will be brought into the site and will be placed and mixed over the top of the lysimeters to form the cap layer. Seven different one acre plots will be set-up with differing ratios of fly ash, spent bed, and either GOB or soil material. Layers of GOB, soil, and FBC byproducts will be placed in lifts and then mixed by heavy equipment.

Following cap placement, a covering of topsoil will be placed. Next the cap and topsoil will be cored to provide samples for the assessment of mixing, and to provide holes for the

placement of subsidence monuments. FBC materials are expansive when wetted and the subsidence monuments will be surveyed in and used as a measure of heave and swell during curing. Lysimeters and wells will be checked for indications of water infiltration through the cap. Briar Creek will be monitored for indications of impacts of acid seepage from the GOB.

RESULTS AND DISCUSSION

After coordinating and planning with the contractor as the spring season began, lysimeter installation was to take place the week of May 9th, with dust control experiments beginning at about the same time. April and May, however, have been very wet months this year and the contractor has been unable to operate his equipment on the site most of the time. The contractor has succeeded in rebuilding the haul road for the fly ash deliveries, although it must still be graveled. The contractor has also succeeded in filling the pit half way up to subgrade level. Archer Daniels Midland has awarded a new contract for the fly ash deliveries (the contract from last fall having expired).

Because construction work on the cap was to have begun this quarter, most of the materials, supplies and equipment are now lying in a state of readiness. This includes the lysimeter materials. After discussions with the contractor it was decided to have the lysimeters installed by graduate student and researcher work crews, including the backhoe work for lysimeter placement and trenching. The paper work for backhoe rental has been processed.

Also completed this quarter has been most of the work for the microfoam dust control experiments. Trips were made to Springfield to work with IEPA on calibrating the two high volume air samplers that were already here, and to obtain two more high volume air samplers. The dust control network will now consist of 4 high volume air samplers, a respirable dust monitor, video recording equipment, and the generators to operate the high volume samplers.

A special trip was made to Kentucky to observe a commercial microfoam dust control facility at a power plant. The same type of foam generator will be used at the Thunderbird site. The Thunderbird operation, however, includes several features not previously tested at a commercial scale. Because this is a construction site, the foam dispensing and generating equipment cannot be fixed in enclosed areas. Instead, this last quarter, designs have been completed for clamp on spray bars to be attached to the trucks. All foam generation equipment is to be mounted on a trailer towed by a pickup truck. Plans for field handling have been worked out with the contractor.

Another unique feature of FBC dust control is that the material is highly reactive with water. The easiest way to control conventional fly ash dusting is to apply water sprays or microfoam at the power plant. Once fully wetted in the fixed enclosed facilities at the power plant, the ash remains relatively wet and dust free for subsequent handling and transportation operations. With FBC fly ash, this is not the case. Surficial water applied as a spray of foam will rapidly be consumed in hydration reactions with portlandite, allowing the material to

return to a dry and dusty state if treated at the power plant. Experiments at SIUC have shown that FBC fly ash will fully consume just short of 30% of its own weight in water. Further, even if initial wetting with foam was used at the power plant, followed by heavy wetting with water sprays, if 30% water was added the material would become dangerously hot in the truck, and would cement into a block in a transit as long as from Decatur to Southern Illinois. The FBC ash must be field treated with foam to eliminate dusting during the dumping operation, and then heavily wetted on the ground for mixing and placement. Actual operations at the field site will be challenging, however, all contractors involved in the operation remain confident that success will be achieved in this project. It is likely that many variations will have to be used to find a sequence that works, which is a key part of this demonstration project.

Other activities this quarter include the continuing sampling of Briar Creek and acquisition of a backup control computer for the ICP used in water analysis.

CONCLUSIONS AND RECOMMENDATIONS

The weather has pushed back construction of the cap at Thunderbird into the spring. The delay will significantly enhance the baseline water quality data available on Briar Creek, but the amount of data on the cap permeability performance has been significantly reduced. Especially damaging is the loss of the main groundwater recharge events in January and February. One of the main purposes of the project is to show that FBC liner resist groundwater infiltration, even for caps of full commercial scale. Showing the blockage of water infiltration during the main groundwater recharge season would be especially valuable in this respect. A project extension has been submitted to ICCI to ensure that this data is collected. The construction work in this project will be completed within the current project time period, and all contractual obligations of the project should be met without difficulty.

DISCLAIMER STATEMENT

This report was prepared by Dr. B. C. Paul of Southern Illinois University at Carbondale with support in part by grants made possible by the U. S. Department of Energy Cooperative Agreement Number DE-FC22-92PC92521 and the Illinois Department of Energy and the Illinois Clean Coal Institute. Neither the Dr. B. C. Paul, or Southern Illinois University at Carbondale, nor any of its subcontractors, nor the Illinois Department of Energy and Natural Resources, Illinois Coal Development Board, Illinois Clean Coal Institute, nor any person acting on behalf of any of the above:

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PROJECT MANAGEMENT REPORT

March 1 through May 31, 1995

Project Title: **USE OF FLUIDIZED BED COMBUSTION BY-PRODUCTS FOR LINERS AND ALKALI SUBSTITUTES**

DOE Cooperative Agreement Number: DE-FC22-92PC92521 (Year 3)
ICCI Project Number: 94-1/3.1B-5M
Principal Investigator: Dr. Bradley C. Paul, Department of Mining Engineering, Southern Illinois University at Carbondale
Other Investigators: Dr. S. Esling, Southern Illinois University at Carbondale; Mr. F. Pisani, Illinois Abandoned Mined Lands Reclamation Council; Mr. T. Wells, Archer Daniels Midland
Project Manager: Dr. Dan Banerjee, Illinois Clean Coal Institute

COMMENTS

In terms of key milestones this project remains significantly behind schedule. This is a field demonstration project to be completed with conventional construction equipment in a field site with soft underfoot conditions and unpaved dirt road access. As with any commercial scale field construction, weather conditions can, and in this case have, interfered with the original schedule. Good use of the delays have been made to expand the baseline monitoring of Briar Creek and to allow set-up of a much more elaborate dust control demonstration than was originally intended. If the project continues into next year, the delays will probably result in a demonstration of higher quality in greater commercialization value.

Several procedural changes will affect the project budget in terms of the funding required on various categories. Originally it was proposed to house the field work crews during construction and subsequent monitoring in local motels, due to the long work days required. An apartment in the town of Crab Orchard has been rented and will be used as the field base of operations. It is closer than motel facilities and will be less expensive. It will require a budget adjustment to move funds from the travel line to the contractual services.

In discussions with the contractor, Richardson Excavating, it was decided that it would be more convenient to have the lysimeter placement work done by research crews. The dust control system proposed by Richardson was both late in being submitted and was deemed by the researchers on this project and AML personnel as likely to fail. As a result, \$7,000 of construction and fabrication work originally intended for Richardson have been shifted. DeTer Company has been retained to build the dust control system to be demonstrated, and EZ Rental has been contracted to supply a backhoe to be used by the research crews. The requisition to Richardson has been left in tact in case special construction work is needed at the site. Early in June as the requisitions are actually executed, project expenditures on the contractual service line will exceed original levels consuming part of the travel savings.

Budget adjustments will be required in June but will involve only shifting of funds between lines and not an increase in project cost.

The delay in the project is anticipated to leave sum funds unused by the end of August. A project extension will be requested to allow these funds to pay for a longer period of post cap placement monitoring. Final budget adjustments between lines will probably be submitted in late July when the final cost of the field contractual services has been established.

PROJECTED AND ESTIMATED EXPENDITURES BY QUARTER

Quarter*	Types of Cost	Direct Labor	Fringe Benefits	Materials and Supplies	Travel	Major Equipment	Other Direct Costs	Indirect Cost	Total
Sept. 1, 1994 to Nov. 30, 1994	Projected	6,876	420	8,860	8,325	2,400	19,075	4,356	50,312
	Estimated	1,320	0	770	0	1,360	0	209	3,659
Sept. 1, 1994 to Feb. 28, 1995	Projected	14,484	840	9,560	8,550	2,400	19,720	5,275	60,829
	Estimated	3,341	0	1,357	389	1,360	7,067	1,351	14,865
Sept. 1, 1994 to May 31, 1995	Projected	19,794	840	10,360	8,775	2,400	20,965	6,073	69,207
	Estimated	4,084	0	1,687	389	1,360	7,067	1,459	16,046
Sept. 1, 1994 to Aug. 31, 1995	Projected	40,666	4,182	11,160	10,000	2,400	21,610	9,002	99,020
	Estimated								

*Cumulative by Quarter

CUMULATIVE COSTS BY QUARTER

Use of Fluidized Bed Combustion By-Products for Liners and Alkali Substitutes

● = Projected Expenditures -----
▲ = Actual Expenditures _____

Total Illinois Clean Coal Institute Award \$99,020

SCHEDULE OF PROJECT MILESTONES

Hypothetical Milestones:

- A: Construction and Placement of Liners
- B: Construction and Placement of Wells and Lysimeters
- C: Installation of Survey Network
- D: Twice Monthly Site Monitoring (water and swell)
- E: Data Analysis
- F: ICCI Reports