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Contractor:
Dravo Lime Co.
3600 Neville
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Contract Number:
DE-FC21-91MC28060

Conference Title:
11th International Symposium on Use and Management of Coal Combustion By-Products

Conference Location:
Orlando, Florida

Conference Dates:
January 15-19, 1995

Conference Sponsor:
American Coal Ash Association & EPRI
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A FIELD DEMONSTRATION OF THE USE OF WET AND DRY SCRUBBER SLUDGES IN ENGINEERED STRUCTURES

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Abstract

In a research program being performed at The Ohio State University, the agronomic and engineering properties of flue gas desulfurization by-products are being evaluated. The purpose of this project is to identify potentially beneficial uses for these materials and in so doing reduce the amount of by-product that must be disposed of in landfills. The results of the experimental program have demonstrated that FGD by-products possess the physical properties that should make them suitable for use as a select fill in a variety of construction projects. To verify the laboratory findings on a larger scale, work was begun on a number of field demonstration projects in which the behavior of the FGD could be evaluated under actual field conditions. Two of these field projects were conducted at an Ohio State University research farm where both wet and dry FGD materials were used to stabilize the soil bases in cattle feedlots.

Ash from American Electric Power's Tidd PFBC plant in Brilliant, Ohio was placed in three lots each designed to accommodate approximately fifty animals. Stabilized wet scrubber sludge from AEP's Conesville, Ohio plant was placed at two hay bale storage and winter feeding sites. The construction of the test plots is described. Visual inspections of the plots as well as laboratory tests on samples of the by-product collected at several times during the months since the FGD bases were installed have shown that, in general, the materials have performed satisfactorily.
Introduction

As part of an ongoing research project being conducted at The Ohio State University, we have identified a number of viable alternatives to the disposal in landfills of flue gas desulfurization (FGD) waste, which is a coal combustion by-product. Laboratory tests conducted in the Department of Civil Engineering on samples of FGD material have determined the most important engineering properties including optimum moisture and density levels, unconfined compressive strength, swell and consolidation, and permeability. All tests have been conducted according to the procedures specified by ASTM. These results can be found summarized in Bigham et al. With these test results, we have shown that, in the laboratory, the by-products of dry FGD processes possess adequate strength to be suitable replacements for select soil in engineered earth structures such as embankments and backfills. Our laboratory tests have also shown that, when stabilized by the addition of fly ash and lime, the by-products of wet FGD processes have the strength and stiffness characteristics necessary to replace natural soil in these types of facilities. In an illustration of the range of beneficial uses for these by-products, we constructed FGD stabilized bases and wearing surfaces in animal pens. Compressive strength tests have shown that the material should be able to carry the loads applied by the animals in the lot as well as the equipment typically used to clean these facilities. Permeability tests indicate a very low permeability, reducing the chance that surface water containing animal waste would percolate into the groundwater.

EORDC Bull and Ram Test Station

The Ohio State University operates a research farm (the Eastern Ohio Resource Development Center) near Belle Valley, in Noble County which is in southeastern Ohio. One of the primary activities at the center has been a long running study to observe the effects of several factors on the growth rate of bulls. Twice a year, young bulls are brought to the center and raised in feed lots where their growth can be closely monitored and their diets can be carefully controlled. The feed lots, which are not covered, have always had problems with too much water getting into the soil floors and causing the bulls to sink into the "mud". This lack of stable footing causes increases of as much as 35% in the energy an individual bull must expend just to move to and from the feed troughs. The result has been higher feed costs and significantly reduced weight gains. By stabilizing the floors of feedlots, one important uncontrolled variable would be removed from the study, and the performance of the animals would be improved with more uniform energy requirements. The quality of the conclusions drawn from the EORDC studies should also increase since correlations between cycles would not have to take into account the different ways changing climatic conditions might influenced the stability of the feed lot floor. More importantly for the economy of the region, the identification of a reliable and economical method for stabilizing feedlot floors could reduce substantially the cost of raising beef cattle in high rainfall areas such as Ohio.

Dry FGD by-Products

The site chosen for the demonstration using the dry Tidd ash consisted of three adjacent pens with a total area of 1300m². The soil floor had high water and organic material content
resulting in very low strength. This low strength made it necessary to stabilize the natural material before the FGD wearing surface could be placed. The stabilization was accomplished by field mixing the in-place soil with dry cyclone ash from the Tidd PFBC plant. As shown in Figure 1, this was done by blending the dry ash into the top 20 cm of the in-place soil and compacting the mixture. Once each pen was treated, strength gains in the amended soil were fairly rapid. As can be seen in Figure 2, which shows a loaded dump truck backing onto one of the treated pens to deliver the first load of FGD to be placed as the wearing surface, this procedure produced a suitable platform for the placement of the surface course.

Figure 1. Disking in the Dry Tidd Cyclone Ash at EORDC Bull Test Feed Lot
A cover of 20 to 30 cm of blended cyclone and bottom ash by-products was placed over the stabilized base. All the field placement and compaction activities were performed by regular EORDC personnel using standard farm equipment. Weather conditions and equipment problems experienced during this phase of the project resulted in compacted densities of only about 85 to 90% of the Standard Proctor density with moisture contents ranging from 8% below to 10% above the laboratory determined optimum condition. Figure 3 shows the completed feedlots prior to the introduction of cattle. Delays in the construction process forced the EORDC managers to place cattle in the pens only seven days after the FGD was compacted rather than the 28 days our laboratory investigation showed would be desirable. In spite of these difficulties, only minor failures were observed in isolated areas in two of the three pens after the first cycle of animals was completed. These problem areas were repaired before the second cycle of animals was brought in. After the second cycle, some minor spalling was found at the joint between the FGD by-product base and a concrete apron on which the feed bins are located. No other problems have been observed. After only a few cycles, the conclusions to be drawn are only tentative, but it appears that the PFBC ash does reach high enough strengths to warrant serious consideration as a soil amendment and/or replacement, even in the harsh environment and high loadings present at the EORDC feedlots. Figure 4 shows the finished feedlots with cattle in two of the three pens.
Figure 3. Finished Feedlot Prior to the Introduction of Cattle

Figure 4. Cattle Feedlots in Use
Due in large part to the success of the PFBC demonstration, two additional projects were initiated at EORDC. In these demonstrations, approximately 1200 metric tons of wet scrubber sludge and flyash from AEP's Conesville plant were mixed with additional lime and used to construct two 1200 m² pads used to store hay bails for winter feeding of cattle. The construction of these sites began in late August 1993 with the stripping of ground cover and was completed later that year. Figure 5 depicts the arrival on site of the stabilized Conesville scrubber sludge.

The wet FGD by-products shown in Figure 5 arrived with a moisture content as high as 66% (measurements made on a dry weight basis). The optimum moisture content for this material was determined in the laboratory to be close to 40%. Because the material would not compact properly at the delivered water contents, an attempt was made to get the material down to workable moisture levels by allowing some additional drying time on site. Figure 6 shows the process used to mix additional lime with the FGD prior to compaction. On average, 5% by weight additional lime was added to the stabilized FGD in this manner. Figure 7 shows the FGD material being compacted. When finally compacted, the water contents were still high and the dry densities of the field samples which ranged from 0.54 g/cm³ to 0.79 g/cm³, were significantly lower than the laboratory optimum value of 0.85 g/cm³. The low densities actually achieved and the wide range of densities and moistures measured is indicative of how difficult it is to insure uniform conditions in the field.
Once reacted with the lime, the 14 day moisture content in lab samples dropped to 48%, with compression strengths as high as 2,000 kPa. The laboratory compressive strengths that have been measured on the FGD placed in the feedlots have shown some considerable variability, but because the strengths are high, the early results are encouraging. It is also interesting to note that after a sample was loaded to failure, if the test was continued, the material behavior tended to be characterized by a high residual strength. What we found was that the samples typically retained a substantial portion of their compressive strength (approximately 1,100 to 1,300 kPa) until well after the peak strength is past. This means that failures that would result from overloading would likely remain localized making any repairs simpler. The pads were used for bail storage and feeding this past winter and in spite of the difficulties encountered during construction, the pads both performed satisfactorily, see Figure 8.

Figure 6. Field Mixing Additional Lime with the Stabilized Wet FGD
Figure 7. Compacting the Wet FGD

Figure 8. Completed Wet FGD Pad Being Loaded
Summary

In Southeastem Ohio, FGD by-products have been used to enhance cattle feed lots that had experienced significant deterioration due to climatic conditions and large quantities of animal waste. When compared to natural soils, the FGD by-products used in this application have shown high bearing strength and low permeability values, both essential for surface preservation. The non-toxicity of this material allows for its use around livestock and promotes widespread application.

There are several research objectives we hoped to accomplish in these field demonstration tests.
1. To study the handling and placement characteristics of the materials in field applications;
2. To evaluate the performance of the FGD under the repeated application of large stresses resulting from loads applied directly to compacted FGD by-product.
3. To monitor the engineering performance of the compacted fill over time.
4. To demonstrate the viability of operations such as a cattle feed lot in areas where, historically, they have not been economical.

Visual inspections of the plots have continued on a regular basis since construction was completed. In addition, a number of samples have been recovered for laboratory examination. What has been observed in tests on the samples collected is that water contents are typically much higher for the stabilized Conesville FGD than for the Tidd PFBC ash. The Conesville samples have water contents ranging from as low as 42% up to 80% with an average water content of 60% The Tidd PFBC samples have water contents averaging approximately 28%. The compacted density of the Conesville material is considerably lower than the Tidd by-product (1.5 g/cm² vs 1.8 g/cm²). Unconfined compressive strengths also show a wide variability, with laboratory tests conducted on samples taken from the lots yielding results ranging from 350 to 2450 kPa (50 to 350 psi). Much of this variability in strength was probably caused by small cracks in the specimens that resulted from the sampling operations, since our investigations to date have shown that the materials have performed satisfactorily. Monitoring of the performance of the feedlots will continue. Particular attention will be given to identifying the effects of cycles of alternating freeze and thaw on the structural integrity of the FGD materials.

Acknowledgements

The work described in this paper forms part of a project titled "Land Application Uses of Dry FGD By-Product," being performed in the Civil Engineering Department at The Ohio State University. The authors are grateful for the support of the contract sponsor Dravo Lime Company and Mr. Joel Beeghly who is the Program Manager. Principal funding has been provided by the Ohio Coal Development Office and the U.S. Department of Energy, Morgantown Energy Technology Center. Additional funding has been provided by Dravo Lime Co., American Electric Power and Ohio Edison. American Electric Power provided for the delivery of both the dry and wet FGD to the project sites. The construction of the demonstration plots would not have been possible without the efforts of the EORDC staff.
particular, the Center manager Mr. Bob McConnell and assistant manager Mr. Jim Wells. The authors are grateful for their support.

References


