Session IV:

DESIGN/ENGINEERING/PLANNING

Session Chairs:

Y. Paul Chugh
Mining Engineering Department
Southern Illinois University at Carbondale

Gary Brendell
GAI Consultants
Monroeville, Pennsylvania

Panelists:

Gary Dreher
Illinois State Geological Survey
Champaign, Illinois

ASSESSING THE WATER QUALITY IMPACTS OF FLY ASH STRUCTURAL FILL PROJECTS

Joseph E. Bonetti, Ph.D.
Gary F. Brendel, P.E.
GAI Consultants, Inc.
Monroeville, Pennsylvania

Abstract

The beneficial use of coal combustion by-products (CCBs), such as fly ash as structural fill, is becoming more prevalent within the United States. Prior to using fly ash as fill material, many state agencies required an environmental assessment based on comparison of fly ash leachate, as determined by short-term laboratory tests, with a conservative groundwater protection standard. This approach fails to take into account project specific considerations such as volume and composition of fill materials, rates of infiltration, constituent migration and attenuation, existing ground water quality, and present and future groundwater uses. This paper reviews traditional approaches used to characterize potential environmental impacts of fly ash utilization, summarizes recent research findings on the mobility and fate of the constituents of fly ash leachates and suggests adoption of risk-assessments to assess potential environmental impacts at fly ash utilization sites.

Background

Over 1.2 million tons of coal fly ash were used in the United States during 1994 as structural fill material for site development projects, highway embankments, dikes and levees, and other bulk fill applications[1]. Fifteen states have adopted beneficial use regulations or policies allowing fly ash structural fills and similar policies are being considered in other states'. Some of the impetus for this interest in reuse of fly ash derives from the 1993 United States Environmental Protection Agency (USEPA) final regulatory determination on large-volume electric utility wastes[3]. This study found that CCBs, such as fly ash, would not be regulated as hazardous waste and that the beneficial reuse of these by-products should be encouraged. The USEPA further stated it had found no evidence of enviromnental damage resulting from the use of high-volume coal combustion wastes[3].

The use of fly ash in structural fills is currently regulated by the states, many of which require an environmental assessment consisting of a comparison of the fly ash leachate with conservative ground water protection standards. This approach fails to take into account project-specific considerations such as volume and composition of fill materials, rates of infiltration, constituent migration and attenuation rates, existing ground water quality, and present and future land and ground water uses.

This paper will summarize leachate testing procedures which have historically been used to characterize fly ash leachate and discusses the short-comings of the use of these methods when characterizing potential environmental impacts at fly ash utilization sites. As an alternative, the use of risk assessments are proposed to evaluate potential environmental impacts at fly ash utilization sites.

Regulatory Leaching Procedures

Toxicity Characteristic Leaching Procedure

A commonly used test used to determine the leaching characteristics of fly ash is the toxicity characteristic leaching procedure (TCLP). The TCLP test is the USEPA leaching procedure for determining the characteristics of hazardous waste. Land disposal of a material which is determined hazardous using this procedure is not permitted by the USEPA. Many state regulatory agencies have adopted the TCLP for characterization of solid wastes which are not federally regulated. This test was designed to simulate leaching in a sanitary landfill under co-disposal conditions.

The TCLP uses end-over-end agitation, a 20-to-1 liquid-to-solid ratio, and an 18-hour equilibration time. The test uses two leaching solutions. The solution used for the test is determined by the alkalinity of the waste to be leached. Alkaline materials use a solution that has a pH of 2.88 which is buffered using acetic acid and less alkaline materials use a solution with a pH of 4.93 which is buffered using sodium hydroxide.

Synthetic Precipitation Leaching Procedure

The synthetic precipitation leaching procedure (SPLP) is a USEPA test which is designed to determine the mobility of analytes present in samples of soils, wastes and wastewaters with precipitation as the leaching solution. If analysis of the extracted fluid shows that the concentration of any regulated substance exceed the applicable regulatory level, then the material is classified as hazardous.

The SPLP uses end-over-end agitation, a 20-to-1 liquid-to-solid ratio, and an 18-hour equilibration time. The extraction fluid used for the SPLP test is determined by the geographic location of the proposed utilization site. One fluid is specified for simulating leachability of wastes east of the Mississippi River and the other is for simulating leachability of wastes west of the Mississippi River. The extraction fluids are prepared by adding a 60/40 weight percent mixture of sulfuric and nitric acids to reagent water until a specified pH is obtained. The specified pH values are 4.20 ± 0.05 and 5.00 ± 0.05 for east and west of the Mississippi River, respectively.

Other Tests

Synthetic Ground-Water Leaching Procedure

The synthetic ground-water leaching procedure (SGLP) was proposed and developed by Hassett[4]. This method is designed to simulate actual field conditions in utilization scenarios. The test used end-over-end agitation, a 20-to-1 liquid-to-solid ratio and an 18-hour equilibration time. The major differences between this method and the TCLP and the SPLP procedures is the leaching solution. The specified leaching solution is synthetic ground water that has a pH and major cation and anion concentrations that are similar to ground water in the area where utilization is proposed. This test may be performed for a longer period of time to develop information on mineralogical changes in the fly ash which may impact the leachability of constituents.

Discussion of Leaching Tests and Leachate Characteristics

Regulatory tests, such as the TCLP and the SPLP tests, provide information which characterize CCBs as hazardous or non-hazardous substances. However, these tests do not adequately simulate the chemical composition of leachate in real world utilization scenarios.

Non-regulatory tests, such as SGLP, more adequately simulate utilization scenarios. However, this test is limited because it is performed for only a short time period. For laboratory scale tests, properly designed long-term tests (months in duration) provide the most accurate depiction of environmental conditions in utilization scenarios.

Fly ash consists mainly of glass material that is essentially inert. However, materials do exist on the glassy surfaces which are readily exchangeable and may produce leachate when exposed to water. However, leachate which is produced by fly ash is rarely hazardous[5].

The chemical characteristics of the leachate are determined by the chemical and physical characteristics of the ash (which are related to the coal source and the combustion process), and the soil-water medium through which the leachate flows. The principal reactions controlling leachate composition are dissolution/precipitation, adsorption/desorption, and redox transformation'. Wet or dry

placement characteristics also control leachate characteristics because wet placement fly ash materials tend to undergo partial leaching prior to placement.

Major dissolved constituents in the leachate are calcium and sulfate, with lesser amounts of magnesium, sodium, potassium, and silicon. The concentrations of most of these elements in fly ash leachate are a function of leachate pH, with the lowest trace metal levels occurring over the pH range of 6.0 to 8.0[6]. Not all elements in fly ash are equally susceptible to leaching. For example, arsenic, boron, and chromium are preferentially concentrated on and in the surfaces of fly ash particles while lead and other trace elements are preferentially concentrated within the interior matrix of fly ash particles[7]. Elements concentrated on the surfaces of fly ash particles are more susceptible to leaching than the elements concentrated in the interior of the fly ash particles. Therefore the concentrations of these and other individual leachate constituents are dependent upon their availability and reaction chemistry, rather than on their total concentration.?.

Each of the leaching tests described in this paper rely on the fact that water will come in contact with the fly ash material in a utilization scenario. Utilization projects typically place fly ash in a moistened-compacted state, or in a cementitious mix which has a relatively low hydraulic conductivity (low permeability). Low permeability cover materials and surface drainage which limits infiltration are also typically employed at fly ash utilization sites. Each of the above-mentioned factors tend to decrease the amount of surface water and ground water that infiltrates into and moves through the fly ash. Therefore, soluble elements present in fly ash are not exposed to significant quantities of water at properly designed utilization sites and dissolution and transportation of these elements is, therefore, limited.

Several mechanisms in all natural soils and ground waters act to attenuate or reduce the mobility and concentrations of elements in ground water. Mechanisms which contribute to the attenuation process include:

- Precipitation and adsorption with solids
- Dispersion and dilution of ground water

These attenuation mechanisms are predominantly controlled by the pH of the soil, leachate and ground water, the ionic strength of the leachate and ground water, and the physical and chemical characteristics of the porous media. Each of the laboratory leaching tests described in this paper fail to account for these attenuation processes, and these tests consequently do not yield adequate leachate characteristics data.

The inadequacy of short-term laboratory tests is evidenced by the results of several studies which show that the concentrations of trace metals in ground water at disposal sites is lower than the concentrations predicted by laboratory leaching tests'.

The Electric Power Research Institute (EPRI) performed reconnaissance investigations at five road construction sites which used CCBs[9]. These investigations were conducted to gather preliminary information on leaching and migration of chemicals from CCBs to soils, ground water and vegetation. As part of the studies, soil and ash, ground water and vegetation samples were collected and analyzed. The studies concluded that at all sites, regardless of age, climate and soil type, the impact of chemicals leached from fly ash are retained in soils immediately below (0 to 6 feet) the road base or embankment. Therefore, natural attenuation of soluble elements present in the fly ash must have occurred. In addition, the results also suggest that analytes typical of fly ash had concentrations which were either not elevated above background concentrations or were below USEPA drinking water standards.

In summary, short-term tests do not adequately simulate the chemical composition of leachate at fly ash utilization sites. These tests only identify which constituents are most likely to leach under conditions which are typically not encountered in utilization scenarios. Accordingly, long-term

laboratory tests should be used instead of traditional short-term regulatory tests such as the TCLP and the SPLP tests. However, since the chemical makeup of leachate produced by fly ash is variable and is dependent upon the fly ash itself, as well as the conditions present at a particular utilization site, long-term tests also fail to adequately simulate leachate characteristics. Accordingly, each utilization scenario should be evaluated independently based on the characteristics of the particular project, and evaluation of environmental conditions based solely on laboratory tests should be avoided, if possible.

Risk Assessment

Because laboratory tests fail to account for all of the processes that control the fate and transport of elements that originate from fly ash at utilization sites, the use of risk assessments is recommended to predict environmental impacts at proposed fly ash utilization sites. Risk assessments can be performed to determine if the proposed utilization of fly ash poses a significant risk to human health or other ecological populations. Risk is the probability of injury, disease, or death under specific circumstances.

In order for risk to human health to exist, toxic chemicals must be present and humans must be exposed to the toxic chemicals. Therefore, prior to conducting a complete risk assess-ment, an investigator should conduct a qualitative impact assessment for the proposed project. A qualitative impact assessment, based on available information, determines if toxic chemicals are present and if likely receptors are located near the site. If neither of these are present, a risk assessment is probably not required and fly ash utilization will most likely pose no significant risk.

Risk assessments are performed in an attempt to answer one or more of the following questions:

- What chemicals pose significant risks?
- Who may be exposed to the chemicals?
- What are the exposure pathways and frequencies?
- At what concentration can chemicals exist on site without posing an unacceptable risk to the receptors which could be exposed to them?

Risk assessments generally consist of the following steps:

- Data collection and interpretation
- Toxicological evaluation
- Dose-response evaluation
- Exposure assessment
- Risk assessment

Information obtained during the data collection stage include types of contaminants present in the fly ash and site characteristics. This information is typically available from previous investigations and it is supplemented when necessary for the risk assessment[4]. The toxicological evaluation determines whether or not the chemicals identified during the data collection stage could have an undesirable health effect on the target population. The target population usually consists of humans; however, plants, animals and other ecological receptors may be considered. The toxicological evaluation is typically based on published research that identifies the types and severity of potential health hazards associated with specific chemicals.

The dose-response evaluation is performed only if the toxicological evaluation suggest that a chemical may have adverse impacts on the target population. The dose-response evaluation is conducted to investigate relationships among the dose and duration of chemical exposure as well as severity of its adverse health impacts. The result of this evaluation is the identification of a exposure dose that will result in no observed adverse health impacts to the target population. This evaluation often considers chronic or long-term impacts as well as acute or short-term impacts.

An exposure assessment considers actual or potential routes which the target population is most likely to be exposed to or the most susceptible exposure rate as well as the duration of exposure. Typical exposure routes include ingestion, inhalation and dermal contact. This process frequently includes computer modeling of fate and transport of chemicals through air, soil and water to characterize transport pathways and predict actual exposure concentrations. The end result of the exposure assessment is estimates of exposure doses for specific toxic chemicals at potential receptors.

The risk characterization combines all previous steps to estimate the statistical probability that adverse health effects will result in the target population due to exposure. The total potential risks are then compared to levels of acceptable risk which are established by regulatory agencies.

Risk assessments can be applied to fly ash utilization projects by showing that concentrations in air, soil and water will not exceed concentrations that will cause an unacceptable level of risk to exposed populations. Likewise, fly ash utilization projects should be designed so that the level of risk associated with the project is minimized.

Summary

Coal combustion by-products such as fly ash can successfully be used as structural fill. Short-term regulatory laboratory leachate characterization methods such as the TCLP and SPLP tests do not adequately characterize leachate produced by fly ash. At best, these leachate tests simply identify which constituents in fly ash are most likely to leach under conditions that are not typically encountered in utilization scenarios. Long-term non-regulatory laboratory tests provide a more accurate representation of the potential leaching characteristics of fly ash. However, when used alone to predict potential environmental impacts at proposed fly ash utilization sites, both long-term and short-term tests fail to account for site-specific considerations such as volume and composition of fly ash fill material, infiltration rates, constituent migration and attenuation rates, existing ground water quality, and present and future land and ground water uses. When performed and applied properly, risk assessments account for all of the above factors. Therefore, risk assessments should be used to adequately evaluate the potential enviromnental impacts at proposed fly ash utilization sites.

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DESIGN AND MANAGEMENT OF COAL COMBUSTION BY-PRODUCT MINE BACKHAUL PLACEMENT AREAS

William E. Giles
Freeman United Coal Mining Co.
Farmersville, Illinois

Abstract

Mine backhaul operations are a relatively new, but firmly established, way of maintaining viability under increasing competition and regulation. A successful backhaul operation must carefully consider many factors in the design and management of the placement areas. CCB characteristics, site conditions, transportation methods, mine operations and final reclamation plans are among those factors. This paper will try to elaborate on as many of these factors as possible in a short paper.

Disclaimer

Most of the material presented in this paper is drawn from experience and conversations with other people involved in this field. Many generalizations are made, all of which have exceptions. When dealing with coal combustion by-products, familiarity with the particular by-product being handled is necessary to avoid surprises. It is up to the reader to judge whether the information presented here is appropriate to the case at hand.

Overview

The return of coal combustion by-products to an active or inactive coal mine for permanent removal has grown in popularity during the last several years. The ultimate purpose of this type of operation is to reduce the fuel cost to the coal customer. The cost of off site by-product disposal is high enough to warrant serious investigation of beneficial reuse of coal combustion by-products even though the percentage of by-products being reused is still a small number. Mine backhaul operations may be a last resort for many coal consumers when no other economical use exists. In other cases, the amount of coal combustion by-products produced is not large enough to be attractive to by-product consumers. Since most coal is burned by utilities or industrial plants, it is hoped that backhauling will reduce the cost, or at least the rate of rise of the cost, to the consumer. It must be assumed that there is no alternate commercially economical use for the by-products that are brought to the mine, although there may be beneficial uses at the mine level.

Aside from reduced cost, there are several potential benefits to coal combustion by-product backhaul operations. One of these is the potential for land use conservation. If the by-products are returned to the place where the coal was extracted, then the need for land till volume at the customer's site is reduced. If the coal customer was disposing the by-products in a commercial land-fill, then there will be more space available in that landfill for the other types of waste that humans generate. Properties of many coal combustion by-products indicate that there may be uses for them in mine reclamation, subsidence control, acid mine drainage abatement and coal mining waste stabilization. In order to accomplish these things, the cost of mine placement of by-products must be minimized and the long term liabilities of the coal customer and the mining company must be stable and known to all. For these and other reasons, it is very important that the placement plans and operations be well thought out and carried through by knowledgeable people.

The volume of CCB's to be returned to the mine and the length of the term of the backhaul operation are among the first pieces of information necessary. If the coal customer's plant is already in operation, then the normal CCB production can be evaluated. Be aware that changes to the customer's plant or in the method of operation can cause large variations in CCB production rates and that the customer's demand may have wide swings. The basic procedure is to determine the annual volume of CCB's,

the peak volume and the length of the peak. Some coal consumers may want to haul CCB's only on certain days of the week. This may mean large volumes to be handled on those days and minimal volumes on others. An operation with wide swings in CCB handling rates will require a workforce that can respond to rapid changes in workload. It is seldom possible to keep a stable workforce when the activity is volatile and the cost will be high if it is not possible to plan around the peak activity. An important thing to remember is that CCB production continues year round and construction, reclamation and beneficial reuse activities peak in the summer months. When the alternative uses are in operation, the backhaul amounts may fall off. When the alternative uses cease operation, the backhaul quantities may rise quickly. The backhaul activity usually peaks when the weather is so bad that the other uses can't operate. This usually means that the backhaul operation is busiest when the weather conditions are worst. Since the coal customer's CCB storage volume is usually rather small, continued backhaul operation is very important.

A mine backhaul operation must consider the by-product characteristics and properties first. Many generalizations are made about coal combustion by-products, but there are significant differences between different types that may cause difficulties in the operation. Physical and chemical properties must be determined. This includes all the standard tests for chemical constituents, mineralogy, leaching products and engineering physical properties as well as what might be called "offhand observations" about the materials that may determine the suitability of various handling and placement schemes. It is well to be wary of the results of short term laboratory testing when long term results are desired. Coal combustion by-products usually fall into one or more of the following types:

Slag

A vitreous material drawn from the bottom of cyclone boilers. Since slag has been fused, there is very little chemical activity and leachate is not normally contaminated. Slag has many uses including blasting grit, roofing granules and highway traction aid. Slag is normally the major portion of the by-products produced by a cyclone boiler. Very little slag is backhauled unless the particle size is too small to be used in alternate applications.

Bottom Ash

A coarse ash drawn from the bottom of pulverized fuel boilers and stoker fired boilers. This may be partially vitrified or clinkered, but is friable and not suitable for many of the slag applications. Some bottom ash is used for road traction applications. Bottom ash will often show metals in the leachate and may tend to be acid producing. Bottom ash is usually a small portion of the total ash produced by the boiler.

Stoker Ash

An ash drawn from the bottom of grate type burners, a type of bottom ash, but more likely to contain unburned coal particles.

Conventional Flv Ash

A fine dusty ash removed from the flue gases of stoker, pulverized coal or cyclone boilers. This ash will not normally contain spent sorbents. There are two main types of fly ash, Class F (low lime) and Class C (high lime). Class F fly ash is typically associated with eastern U.S. coals and Class C is associated with western U. S. coals. High quality conventional fly ash will contain very little sulfate compounds or unburned carbon. This ash has many uses in cement replacement and flowable or flash fills.

Scrubber Sludge

This is the spent sorbent from flue gas desulfurization scrubbers. It may be dry, but is commonly delivered as filter cake. Scrubber sludge is normally high in calcium sulfites and sulfates. The filter cake may be very difficult to remove from dump trucks or hopper cars. Filter cake is not difficult to handle after dumping, but is soft and usually too wet to compact. Some scrubber sludge is suitable for use as gypsum board feed stock, but much is not reused at present.

Fluidized Bed Fly Ash

This is the ash collected from the flue gas of fluidized bed boilers. This ash resembles conventional fly ash, but contains spent sorbent and is produced at lower temperatures. FBC fly ash is normally highly alkaline and can be used to treat acid producing mine waste. The high alkalinity tends to minimize metals in the leachate. High sulfate content can make FBC fly ash unsuitable for many structural applications. Sulfate may be present as anhydrite which expands as it is converted to gypsum, a process which may take some time. The mineral ettringite is commonly formed during the hydration of FBC fly ash and is generally considered undesirable in concrete mixes. FBC fly ash may gain considerable strength on hydration, but usually weathers considerably when exposed to air, moisture and freeze-thaw cycling. The strength and rate of gain of strength of FBC fly ash appears to be related to the amount of water used to hydrate the ash, in much the same fashion as cement grouts. A low water ratio will usually produce higher strengths as long as sufficient water is used. FBC fly ash usually releases considerable heat on hydration. This heat can cause temperatures exceeding the boiling point of water in a matter of minutes and must be considered in any placement scheme. It may be desirable to hydrate the ash in stages with cooling between stages. Unconditioned FBC fly ash will usually contain considerable dust, much of which may be under 10 microns particle size. During hydration, ash particles react with water and may break down, resulting in new dust unless there is enough water to bind the particles together.

Fluid Bed Boiler Spent Bed

This is excess bed material that must be removed from the boiler to hold the bed level constant. The composition of spent bed should normally be the same as the active bed material and spent bed usually contains considerable unreacted sorbent. Spent bed is normally withdrawn after the fly ash has been removed and is not normally very dusty. Spent bed may be used as a low cost low grade lime substitute.

There are two basic types of operations that will be discussed. The first is an operation that places CCB's in the same place that the coal was extracted from, that is, in seam. The most common operation of this type is to place the CCB's against a highwall in a stripping operation. Coal waste products may be mixed with the CCB's or CCB's may be incorporated in the spoil. This is usually done when the spoil is potentially acid producing. Another option is injection of CCB's into underground workings for subsidence or acid mine drainage control. This is not yet common, but is being done. The second type of operation is that where the CCB's are placed in an area developed specifically for that purpose. Again, coal waste products may be, and usually are, mixed with the CCB's. The resulting mixture may have properties superior to the individual components. CCB's may be used to stabilize coal processing wastes or to reduce the acid producing potential of these wastes.

There are two general types of placement methods, dry and wet. Dry placement is any method that results in a solid material that does not bleed water. Wet placement is any method that results in an excess of water that must handled after the CCB's have been placed. There is a gray area where the CCB's are placed as a paste, but the water is consumed in hydration, much the same as placing concrete or flowable fill. Each method has advantages and disadvantages. Dry placement may avoid leaching, but the CCB's may not be compactable and dust may be a problem. Wet placing avoids dust, but may not flow as well as expected or may result in a low strength material. In the end, CCB's may be placed dry,

just as received, with water added to control dust and aid compaction or wet as a paste or slurry, all at the same site. The decision is based on the lowest cost after evaluating the materials, the site, the equipment and the operational hazards.

Preliminary Evaluation

One of the first CCB properties to determine is the in place density of the CCB's. This is not necessarily the same thing as the as received bulk density. Moisture may be added or removed. Mineralogical changes may occur. Compaction may take place, but be offset by expansion due to changes in the structure of the CCB's. If CCB's and coal mine waste products are blended, the resulting mixture may have properties quite different from the original constituents. After all of these have been considered, it is hoped that the volume occupied by one ton of CCB is known and the volume required to hold the total amount of CCB's expected during the term of the contract can be calculated. This calculation is not a trivial thing and needs to be updated periodically to avoid end of term surprises.

Site conditions must be evaluated. The site location will normally be dictated by proximity to mine operations and the backhaul operation will be tailored to the site. If the mining operation already exists, many of these conditions will be known. Site topography, surface and ground water sources must be evaluated. Existing water quality and hydrological conditions should be determined. Soil types and properties must be investigated. The mining operations plan may have an effect on the by-product handling plan.

If the CCB's are to be placed in an excavation or earth embankment, the permeability and nature of the groundwater flow must be determined before proceeding. The current tendency is to restrict groundwater flow through CCB placements, but there are cases where groundwater has been improved by passing through CCB's. There are cases where CCB's are being placed on the ground surface with conventional earthmoving equipment, the only water handling being perimeter berms and ditches leading to a settling pond. Periodic soil cover and revegetation serve to limit the infiltration of water into the CCB's. Encased fills are sometimes allowed under beneficial reuse regulations. Some regulations require that the CCB's be placed above the water table, but exceptions may be allowed. The quantity, quality and current use of the groundwater will help guide the operator in the choices. Background monitoring of groundwater is generally required before placement operations can begin. Periodic monitoring during placement is also required. Considering the wide variations in soil types and CCB's, it is not really possible to generalize about construction methods and requirements. The methods currently used for coal refuse disposal areas, impoundments and embankments are all generally applicable to CCB's, but the specific cases have to be considered.

If the CCB's are to be placed against a highwall or in a pit at an active stripping operation, different groundwater considerations are presented. Beyond the highwall, natural conditions prevail. Unless the ground is highly fractured, the flow may tend to be parallel to the bedding planes of the strata. In the spoil, there is no set pattern of groundwater flow. Where the mine is on hilly ground, water may flow into the spoil on the upstream side, down through the spoil and exit at the toe. Where the pit is on level ground, there may not be any obvious groundwater flow. Water may infiltrate the spoil from the surface until saturation is reached. In underground mines, the CCB's will typically be pumped from the surface into old works. If the coal seam outcrops and there is surface water flow into the old works, the CCB's may seal the passages that water is flowing through. There are current projects that use CCB's to fill voids in abandoned mines where acid mine drainage is flowing to an outcrop. CCB's could be used to form a barrier to water flow from one underground mine to another. If the old works are dry, a common occurrence where no access to surface water exists, then there will be no contact between CCB's and groundwater. The natural conditions that allow coal to be formed often result in an impermeable layer of rock above the coal seam. As long as an impermeable layer exists and the coal seam is well below any aquifers. the likelihood of groundwater contamination from the CCB's is remote. Mining methods that result in intentional subsidence normally fracture the strata above the coal seam and can allow surface water to penetrate to the coal. This does not preclude the placement of CCB's in these areas, but does

tend to complicate the process. If the CCB's are to be mixed with coal refuse, the groundwater considerations are much the same, but the mixture may behave in a different manner than the individual components.

Transportation methods will probably influence the by-product handling facilities. Most traffic will move to and from the mine by truck or rail. Truck transportation is the most flexible, but over the road trucks may not be appropriate for on site material handling. Rail cars will normally have to be unloaded at a dedicated facility that may or may not be on the mine site. The trucks may also be handled in the same fashion. If the CCB's properties are suitable, it may be possible to unload trucks at the placement site and avoid double handling. Mine operations and the type of mining methods used may influence the choice of the on site material handling system. If haul trucks are used to bring coal from the area where the CCB's are to be placed, then it may be possible to use these same haul trucks to carry the CCB's to the placement site. In any case where the same containers are used to haul both coal and CCB's, care must be exercised in order that cross contamination does not occur. It is not too difficult to see why contamination of the coal product is undesirable, but contamination of the by-products with coal may also be a problem. There are specific cases where coal mining waste and coal combustion by-products will be intentionally placed together. In this case, the properties of the coal waste, by-products and the combination of these materials will need to be evaluated.

Weather can affect backhaul operations in the most direct ways. Construction jobs normally shut down when the weather is too wet or too cold, but backhaul operations have to operate in all types of weather under all sorts of adverse conditions. Reclamation work is probably most productive between the months of April and October. If CCB's are being used to aid reclamation, where do they go in the winter? Sometimes they can be stockpiled and placed later, but this rehandling can get expensive. Power plants run 365 days per year and the operators get pretty upset when the CCB silos are full and the trucks aren't moving. Weather affects backhaul operations in another very important way. Water is almost always a necessary part of the backhaul process. The amount of water required and the point of use vary. Water requirements should receive careful consideration to ensure adequate supplies and economical distribution. Reservoirs may be required to maintain the water supply and by-pass structures may be necessary around the CCB placement areas.

Backhaul **Operations**

A backhaul operation begins at the point where the CCB's are delivered to the mine operator and ends when the coal is loaded into the conveyance. Truck haulage is the most common method of delivery. Trucks are preferred when the haul distance is short and the quantities are reasonable. With large quantities of CCB's, traffic control may become a problem. Rail haulage is used when distances are longer and when quantities are greater. Rail haulage requires a central dumping location and some other method for handling the CCB's on site. In both cases, quantity measurement must be allowed for. In some cases, the shipper Will weigh the conveyances, in others, the mine operator. If neither the shipper nor the receiver has weighing facilities, then some other method may be required. It is important to know the weight of incoming material and may be required by some regulations. Knowing the weight of delivered CCB's and the volume of space required for them is useful for estimating the life of a facility. If specific blends of CCB's and other materials are to be used, the weights will be useful in controlling the mixes.

Truck haulage is the most flexible method of transportation. The truck may dump the CCB's at a central location or may drive to the final destination of the CCB's and then dump. The choice depends on a number of factors. If the conditions on site are not suitable for over the road trucks, the mine operator may want to consider a central dumping location. If the mine haul roads can be maintained in a condition that will allow all weather access and the dump location maintained in a firm and level condition, it is possible to have the trucks dump directly and not have to rehandle the CCB's. This is desirable if no further treatment of the CCB's is necessary and dust is not a problem. Some rail receiving facilities load the CCB's into trucks, both off road and over the road. The trucks then transport the CCB's to the point of USC. The central dumping station may add water to the CCB's or blend the CCB's with other materials,

such as coal processing wastes. The economic analysisand logistics of locating a central dump station are complex. Once a station has been built and placed in operation, it is very difficult to make changes or additions that may be required by changes in traffic or materials.

If the condition of the CCB's at dumping allows conventional earthmoving techniques and equipment to be used, spreading and compaction of the CCB's may be the best approach. If the CCB's require hydration or are uncompactable or powdery and dusty, a useful approach may be to dump against a berm or into a trench or pit and then to cover the CCB's with spoil or other inert material before water is added to hydrate the CCB's. This will contain the dust that might form during hydration and can allow slow penetration of the CCB's with water. Direct spraying of very dusty CCB's may cause airborne dust where the water stream impacts the dust. A gentle sprinkling or misting will be required in these cases. Water may be added with sprinklers and other irrigation equipment. The most common problem encountered with sprinklers and fine sprays is that wind will blow the water in a different direction than that desired. This usually means frequent moving of sprays and piping, a costly and time consuming process. Flood irrigation may cause a crust to form on the CCB's which prevents water penetration into the CCB's. Later excavations may uncover dry dusty material that has not been properly hydrated. Weathering of CCB's may result in surface conditions that are unsuitable for travel by over the road trucks. In some cases fresh CCB's may be used to provide a driving surface. In cold weather, it will be important to provide a location where unhydrated CCB's may remain undisturbed until it becomes warm enough to add water to them. Wet, sticky CCB's may be very difficult to handle in cold weather. Any CCB's that stick in the nose of a semi-trailer may cause the trailer to become unstable and tip over. In some cases, frozen CCB's may be perfectly acceptable as a driving surface, but when thawing starts may become very unstable.

Other transportation modes may be used to remove CCB's to the point of use. These include dilute phase and dense phase pneumatic, conventional slurry and paste pumping. Pneumatic methods are best suited to short hauls that are mostly horizontal. The equipment is expensive, requires high horsepower and the capacity is low. Slurry placement is high capital cost, but low operating cost. The biggest disadvantage of slurries is the amount of water required and the need to handle this water after placement of the CCB's. Slurry system capacity can range from low to high and can operate at low throughput rates, if there is adequate water handling capacity. The low slurry densities require expensive impoundments with room for settling and decant systems for the clarified water. Pipelines can run long distances, but must be capable of being moved at the discharge point as solids collect. At high throughput rates, the pipes may have to be moved quite frequently. The slurries will probably flow over long distances after leaving the pipeline, if there is a favorable gradient, but will eventually build up at the discharge. Paste transportation removes much of the water from the mixture and does not require as much attention to excess water past the discharge, but will not usually flow as well as dilute slurries and requires higher horsepower. Mixing equipment varies from simple to complex. the less water desired in the final mix, the more complex the mixing equipment. If the CCB's are reactive, then multistage mixing may be required. The water may be consumed in the first stage, and considerable heat may be given off. Changes in the behavior of the CCB's may occur as the water content changes. It is much easier to add water to CCB's than to remove it later on, so monitoring the water content during mixing and transportation is the best way to ensure that excessive water is not being used.

Drainage control structures may often be constructed of CCB's. The type of structure desired and the properties of the CCB's will determine the methods of construction. Simple heaped structures are often useful. but will usually leak and are subject to slope failures. It is possible to use a heaped structure to contain a hydraulically placed cementitious CCB till. The voids in the heaped fill are often filled by the flowable mixture and the heaped fill is stabilized. This type of structure can be used as a containment and can be raised in lifts. It is important that the engineering properties of the structure be determined so that stability is maintained. Compacted fill structures may be built with CCB's. Some CCB's are suitable in the as received state. while others may require conditioning. The permeability of these structures may be to high to allow them to be used as impoundments, but they often serve as roadways and windbreaks. Blending CCB's with coal mining or processing wastes may result in a compactable mixture with superior

properties to the individual components. If the coal wastes contain clays, they may help to lower the permeability of the blend, while the CCB's may increase the strength. High lime content CCB's may help reduce the acid forming tendencies of some coal wastes. The weathering properties of these blends may require attention and heaving may occur because of mineralogical changes to the blend. These are not normally considered problems when the materials are used in an active mining and backhaul operation due to the short active life time of the structures.

DESIGN AND CONSTRUCTION GUIDELINES FOR COAL COMBUSTION BY-PRODUCT UTILIZATION IN ABANDONED MINE LAND SETTINGS - A CASE STUDY

Donald L. Bryenton, P.E.
John H. Gasper, P.E.
ATC Associates, Inc.
Indianapolis, IN

Abstract

The Midwestern Abandoned Mine Site is located in the heart of the Illinois Coal Basin in Pike County, Indiana. This site consists of approximately 550 acres of previously surface mined land that adjoins, and in some areas intersects, abandoned deep mine workings in the same coal seam. The most severely impacted portion of this site is located in the vicinity of an abandoned portable preparation plant where exposed coarse and fine coal refuse are surrounded by highwalls, associated final cut pits and poorly vegetated spoil. Due to the limited supply of low-permeability soil in this area the reclamation plans for this site included the use of coal combustion by-products to facilitate and enhance the reclamation program. Poz-O-Tec, a mixture of flyash, flue gas desulfurization (FGD) and quicklime, was used to create a low permeability cover over the exposed coal refuse while a combination of Poz-O-Tec and alkaline coal ash was used to backfill existing highwalls. Locally available mine spoil was used to establish a vegetative cover. This is the first significant application of coal combustion by-products at an abandoned mine land project in Indiana. Approximately 600,000 cubic yards of coal combustion by-products were utilized to meet material requirements at the site. Material properties have met and, in some instances, exceeded the anticipated characteristics. Chemical quality of both groundwater and surface water will be monitored by the Indiana Geological Survey for a two-year period (1997 and 1998). This data will be compared to baseline water quality for evaluation of application viability.

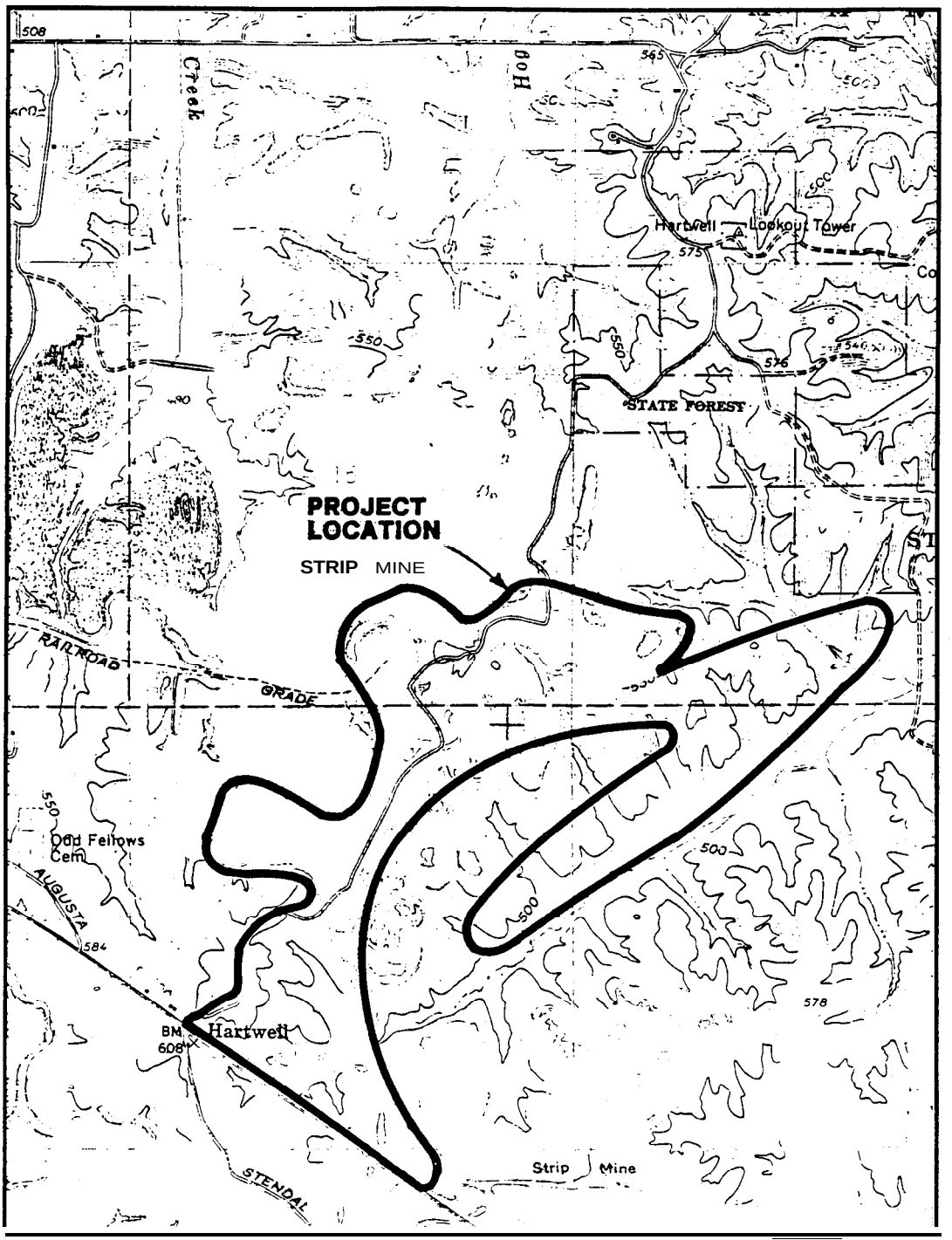
Introduction

The Midwestern Mine Reclamation Project is located within portions of Sections 14, and 27 of Township 2S and Range 7W in Pike County, Indiana, approximately 4 miles east of Arthur. As illustrated in Figure 1, the project area is generally bounded by State Route 64 to the south an unnamed tributary to the Patoka River to the east and Pike County State Forest to the north.

The Midwestern Mine Site is positioned within a 6000 acre tract of land referred to as the Mill Creek Abandoned Mine Land Area that was initially investigated and partially reclaimed in the early 1980's as part of Indiana's Abandoned Mine Land Program. Much of the area that was reclaimed was subsequently deeded to the State of Indiana and incorporated into the Pike County State Forest. Due to the presence of the state forest and adjoining surface mined areas that have been reclaimed to enhance the wildlife setting, the Mill Creek area has significant value as a wildlife habitat. The 550 acre Midwestern Mine Site was not eligible for funding through the abandoned mine land program at the time of the Mill Creek Reclamation Project but has since become eligible due to bond forfeiture. ATC Associates, Inc. (ATC) prepared the reclamation plan for the Mill Creek area and was retained by the Indiana Department of Natural Resources Division of Reclamation (IDNR-DOR) to prepare design plans and specifications and provide construction support services for the Midwestern Mine Site.

The intent of the current reclamation project is to improve site safety conditions by backfilling or removing dangerous highwalls, to lessen the potential for acid mine drainage, to dispose of derelict mining equipment and to reduce erosion by regrading and revegetating disturbed areas. Additionally, the project includes the construction of new wetlands and improvements to existing wetlands and ponds to enhance the wildlife habitats.

Figure 1. Location Map



TAKEN FROM: U.S.G.S. AUGUSTA, INDIANA 7.5 MIN. TOPOGRAPHIC QUADRANGLE
SCALE: 1 INCH = 2000 FEET

The project was divided into six reclamation sites, five of which generally consist of a combination of poorly graded unvegetated mine spoil, exposed highwalls and acidic ponds in final cut pits. The sixth site, which is the focus of this case study, is located in the vicinity of an abandoned portable preparation plant and generally consists of exposed coal refuse, unreclaimed minespoil, exposed highwalls, unreclaimed slury ponds, areas of ponded water next to the exposed highwalls and within the minespoil, and acid seepage from abandoned underground mine workings.

The initial reclamation plan for this area included the regrading of the mine spoil, backfilling of the highwalls and the consolidation and covering of the exposed mine refuse. However, investigations of the areas within and immediately surrounding this site revealed a shortage of low-permeability cohesive soils for use in covering the coal refuse. Further, the quantity of borrow material needed to backfill the highwalls and to create the preferred surface drainage conditions would require the disturbance of a large area of adjoining mine spoil that, although poorly graded, was heavily vegetated. The only locally available borrow area that was not mine spoil was located within mature wooded areas that have significant wildlife value.

After reviewing the reclamation plan and the limitations regarding locally available borrow materials with the IDNR-DOR, it was agreed that off-site borrow sources should be evaluated before proceeding with the project. To date, IDNR-DOR has permitted the use of coal combustion by-products (CCB) in the reclamation of active mine sites but these materials have not been used in the reclamation of any large abandoned mine land sites. However, IDNR-DOR had been discussing the possibility of using CCB on AML reclamation projects with utility companies located within the coal region of Indiana and was looking for an area that could be used as a demonstration site to determine the suitability of using these materials on future AML reclamation projects. Given the close proximity of the Midwestern Site to the Indianapolis Power and Light's (IPL) Petersburg Generating Station (18.5 road miles) and the desirable characteristics of the CCB, it was agreed that the use of these materials on this project would be beneficial in enhancing the quality of the water discharged from this site while providing a reliable borrow source. Further, the use of these materials would limit the disturbance of adjoining wooded areas of both previously mined and undisturbed lands.

Since this project will serve to demonstrate the suitability of using CCB materials on future AML projects, it was agreed that it would be prudent to limit its use to one area to facilitate the monitoring of the long term impact of these materials on both surface water runoff and ground water quality. Therefore, the use of the CCB materials will be limited to the area surrounding the abandoned portable preparation plant since all of the surface runoff and at least some of the ground water appear to flow toward a slow meandering wetland area of an unnamed tributary to the Patoka River which borders the east side of the Midwestern Site.

Utilization of Coal Combustion By-Products: Review of Available Data

Once it wasagreed that the use of CCB's appeared to be a viable reclamation alternative at this site, a literature review was performed. Further, state, federal and coal ash advocate organizations were solicited for case studies and other relevant data. A review of state and federal regulations was also performed to verify that these materials could be utilized for this purpose without obtaining variances or exclusions from agencies other than IDNR. A bibliography of relevant reports is provided at the end of this paper.

IDNR-DOR reviewed the results of laboratory tests provided by IPL to evaluate both the short and long term leaching of deionized and acidified water through various CCB materials. The results of these tests were well within tolerances set by IDNR-DOR for the use of CCB in the reclamation of mined lands. Quarterly testing of the CCB was completed during the active period of reclamation to confii the consistency of the material.

Three site visits were also undertaken to view production and utilization conditions of the various CCB. The IPL Generating Station located 18.5 miles from the project was first visited to observe the manufacture of Poz-O-Tec It was evident during the site visit that the various components of Poz-O-Tec could be easily modified depending upon requirements dictated by site and/or haulage conditions. For example, additional quicklime could easily be added during cold conditions to catalyze the pozzolanic reaction.

Three areas within the plant were inspected to determine handling, placement and long term strength characteristics of various CCB. The first area observed was an area in which Poz-O-Tec was being placed for structual fill. Compactive effort requirements, and the need to roll the site with a smooth drum vibratory roller prior to precipitation events were reviewed with the site personnel

The second area observed within the plant was the current IPL restricted waste landfill where CCBs of various curing ages were excavated to determine long term materials properties of compacted Poz-O-Tec, flyash and bottom ash. Observations of one year old compacted Poz-O-Tec revealed material with compressive strengths that are comparable to weak shales. It was also evident that bottom ash and flyash could also be successfully placed as long as no large areas of predominately flyash material were placed in marginally stable areas.

The third area observed during the plant visit was the ash storage ponds where bottom ash and flyash were being decanted. Once decanted, the surface of the ash generally provided a stable driving and/or loading surface. Rubber tired hydraulic excavators are suitable for loading trucks while providing the opportunity for selective handling of the materials excavated. The ash appeared to be highly erosive and could cause significant dust problems if not periodically wetted. Therefore, a water truck was required at both the loading area and in the placement area of the mine site. Surface water runoff was also routed, to the extent practicable, around the placed CCB and cohesive soil cover and channel lining was placed to keep the materials from eroding.

In addition to the observations made at the IPL facility, A site visit was also made to an Indianapolis area project site where coal ash (bottom ash and flyash) was being used in the construction of an interstate highway on-ramp. The contractor was interviewed to determine handling and placement characteristics of the coal ash. Loading and unloading of the CCB were observed at the local power plant and the construction site, respectively.

Upon significant completion of the reclamation effort involving CCB utilization, the contractor and the INDR-DOR project manager were interviewed to assess potential problem areas associated with using CCB's in an abandoned mine land setting. These observations are site specific, by have been included to help identify some actual working constraints identified during the construction process. Some of the constraints include the following:

1. Daily Delivery Rate: A minimum of 150 triaxle truck loads per day were needed in order to justify dedicating full-time manpower and equipment to both loading and placing the materials.

2. Daily Requirements at the Site: The daily requirements varied significantly depending upon the geometric constraints in the placement zone.

3. Erodibility: The materials are highly erosive. However, a series of three decant structures protected the off-site discharge of CCB's even during a very wet spring that recorded at least five 2.5year storm events.

4. Winter Handling, Poz-O-Tec: Poz-O-Tec placement in the winter could be achieved on almost all days. Care should be taken to avoid excessive FGD sludge and to maintain quick lime content between 1.5 and 2.0 percent. Truck tire embedment was much greater in the winter (up to 1 foot) than in summer months (1 to 3 inches) because of the slowed curing time of the Poz-O-Tec.

5. Winter Handling. Coal Ash: Because the coal ash was obtained from an ash pond setting, water draining from the trucks led to slick, icy patches forming along the haulage route. The coal ash also tended to freeze up in the trucks to the point that a backhoe had to be utilized to empty the trucks. Because of these constraints, it is recommended that no coal ash be hauled when the outside air temperature is below approximately 20 degrees Fahrenheit.

6. Wet Handling Conditions: Approximately 24 hours of dry weather were required after a significant precipitation event before additional CCB's could be placed and adequately compacted.

7. Haulage Cycle Time: Because of congestion at traffic signs and through small towns, the trucks along the haulage mute tended to bunch up in groups of 3 to 6, decreasing optimum efficiency.

8. Truck Cycle per Day: This varies from site to site. However, on a given day over a specific 18.5 mile haulage mute, truck cycles/day still varied from truck to truck from 6 to 8 truck cycles per day.

9. Unit Weights: Poz-O-Tec has a much lower unit weight than coal ash. The coal ash trucks could not be totally filled because the haulage weight limits of the truck and/or roads and bridges would have been exceeded.

10. Quality Control: Flue gas **desulfurization sludge without the right proportions of flyash and quick** lime **could** not be compacted and reacted like a very wet clayey soil. The process of producing Poz-O-Tec requires start-up time before the proportions are correct. The FGD sludge is generated earlier in the start-up of the process than the flyash is. This FGD sludge should not be hauled to the minesite.

11. Roadways: Pond ash did not provide an adequate base material for roadways within the mine site. The moisture content was too high and the driving surface failed.

The information obtained from the literature review, off-site observations and during construction of the Midwestern AML project was utilized to develop the technical specifications outlined in the following section. The specifications utilized on this project are provided as an example of handling techniques and placement guidelines that could be utilized on similar projects that utilize CCB materials. It is emphasized that the use of these materials and the handling procedures should be evaluated on a case-by-case basis in accordance with all appropriate state and local regulations. The specifications developed for this project emphasize a balance between overhandling of the CCB and uncontrolled placement of the materials to ensure that the cost of using these materials does not exceed the advantages offered by off-site, low-permeability alkaline materials.

It should also be noted that the IDNR-DOR has contracted with the Indiana Geological Survey to establish background data and monitor the site both during and after reclamation to determine the impact of the reclamation effort on the quality of both surface water and ground water in the vicinity of this site. (Reclamation began in the Fall of 1995 and was significantly completed by the Summer of 1996).

Suggested Technical Specifications for the Utilization of CCB Materials

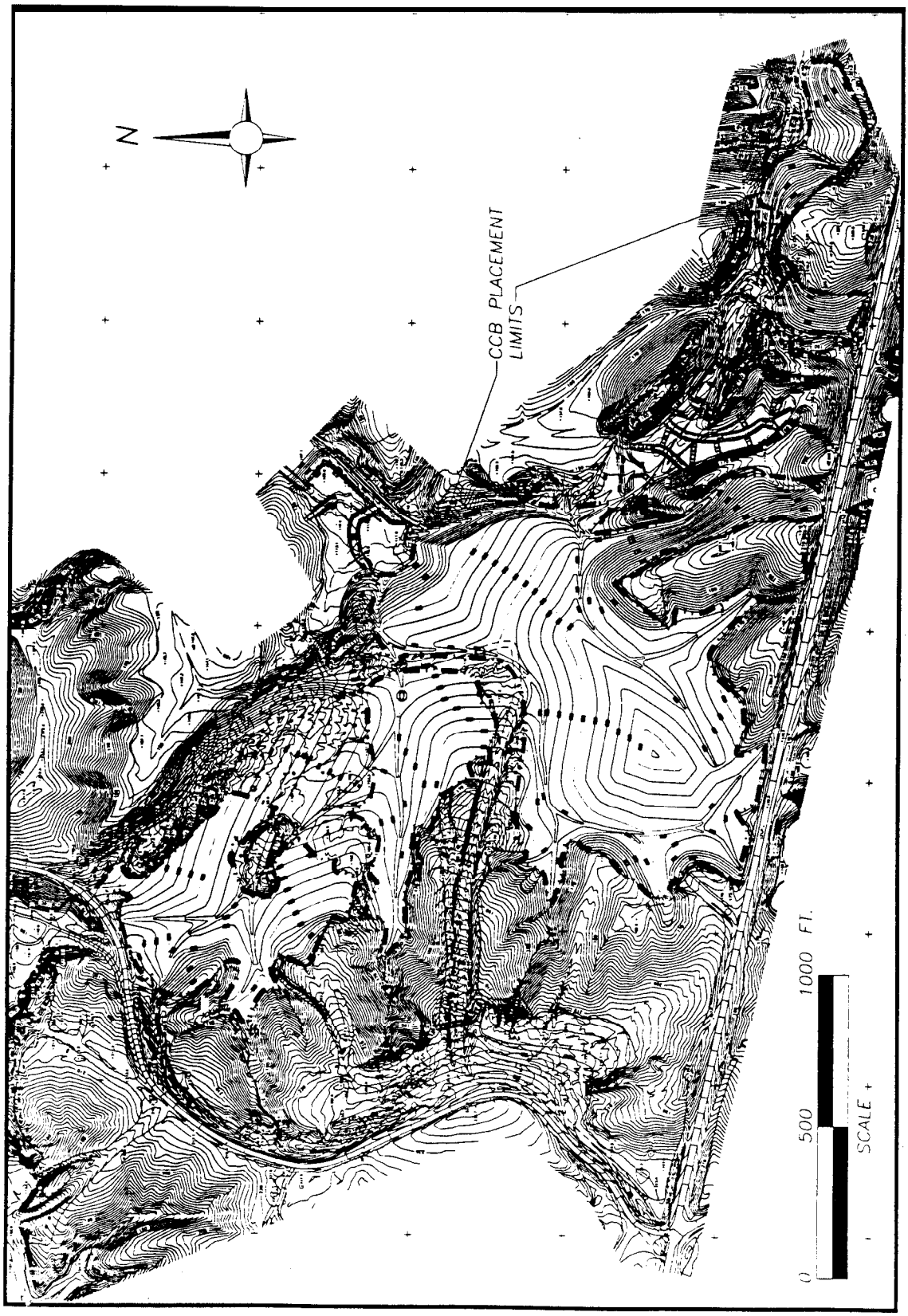
Scope

The work shall consist of the placing, compacting and covering of Coal Combustion By-products (CCB). For purposes of this project, the Coal Combustion By-products shall consist of

- Coal Ash - A general term used in these specifications to refer to all inorganic materials (including, for the most part, bottom ash flyash and natural soil in varying ratios) contained in the ash ponds at the borrow source.

- Poz-O-Tec - A manufactured material that typically consists of a ratio of 1 part flue gas desulfurization sludge ($CaSO_3$) to 0.6 to 1 part flyash to 1.5 to 2.0 percent quicklime (CaO) which is added as a catalyst

Figure 2. Coal Combustion By-Product Placement Plan



The design intent is to utilize the coal ash and Poz-O-Tec as grade-raise fill in final cut pits to eliminate existing highwalls and acidic ponds within the project limits as illustrated on Figure 2. The Poz-O-Tec will also be used to form a low permeability layer above the coal refuse to reduce surface water infiltration and oxidation potential of the coal refuse. Once the materials have been placed to the grades indicated on the drawings, they shall be covered with a minimum of 3 ft of minespoil and/or natural soils and the area seeded in accordance with the appropriate Technical Specifications.

Material Haulage

The contractor shah construct, improve and maintain haul roads within the project limits at the locations shown on the drawings and augment the haulage route between the borrow site and the project site as required by the state highway department at the time of bidding. At a minimum, this shall consist of upgrading portions of the existing County Road constructing a temporary second lane parallel to a portion of the County Road and creating a haul road that traverses a portion of the site to provide the transport trucks ready access to the areas where the CCB will be spread or stockpiled. The intent is to create a one-way mad system to facilitate the movement of the CCB that will be delivered to the site.

Once the subgmde elevation has been established along the new portions of the mad alignment, the subgmde shall be proofrolled and all soft or otherwise unstable materials removed and replaced with minespoil compacted in 10 inch (maximum) lifts. Once the subgrade has been approved by the engineer, the haul road subgrade shall be covered with geogrid in accordance with the manufacture's specifications. The geogrid shall be covered with a 10 inch lift of No. 2 crushed stone which in turn shall be covered with a 6 inch lift of No. 53 crushed stone.

The contractor shall maintain the entire haul road alignment to facilitate the movement of the truck fleet utilized to transport the CCB. In addition to constructing and maintaining the road alignment shown on the drawings, the contractor shall provide and maintain access to all areas within the site where the CCB materials are being stockpiled or spread. This maintenance program will continue until the transport of all CCB has been completed and shall include, but not be limited to, grading of the road surface, removal of mud from the road surface, dust control, construction and maintenance of temporary diversion ditches to control surface water runoff, and any other haul road maintenance functions deemed necessary by the engineer. In the areas where the haul road alignment will not be graveled, the contractor is advised that it will likely be necessary to build a road base out of compacted minespoil to bridge over existing soft and poorly drained areas. With the approval of the engineer. the contractor may use geogrid to reinforce the bridge lift.

Upon completion of the hauling of the CCB, the surface of the haul road shall be removed and all disturbed areas regraded and revegetated to the satisfaction of the engineer. The crushed stone placed along the non-County Road portion of the haul road alignment shall be salvaged and used within the project limits at an area approved by the engineer (i.e., to resurface portions of the County Road or to stabilize haul roads elsewhere in the project) at no additional cost to the STATE. It is emphasized that the design intent is to discourage pedestrian and vehicular access to the site upon completion of the work. To this end, all access routes (except for the County Road) shah be "reclaimed" and revegetated as indicated on the drawings and elsewhere in these Technical Specifications.

Material Placement

Prior to placing any of the CCB, the contractor shah prepare the surface of the till area in accordance with the Technical Specifications. Further, all existing flooded pits shall be drained in accordance with the Technical Specifications. Unless otherwise directed by the Engineer, the CCB shah not be placed, stockpiled or spread into standing water.

Once the surface has been prepared, the CCB shall be placed in the areas shown on the drawings. The CCB shah be spread in 18 inch lifts and compacted with the construction traffic that shall be evenly distributed across the area. It is the contractors responsibility to ensure that enough equipment is available to spread the

material as needed to facilitate its unloading. Rubber tired dozers appear to be best suited for placement and compaction. The coal ash may be stockpiled at a location approved by the engineer for later tmnsport into the fill section by the contractor. Stockpiling of the Poz-O-Tec will not be permitted since it undergoes a pozzolanic reaction similar to that of concrete.Poz-O-Tec shall be spread and compacted within 48 hours of delivery to the site. In the event that the contractor's equipment breaks-down or is not available due to maintenance, etc., the contractor shall provide back-up equipment as needed to continue the placement and compaction of the Poz-O-Tec The contractor is advised that it will typically not be possible to postpone the delivery of the Poz-O-Tec.

The graded surface of the CCB shall be compacted with a minimum of two passes of a smooth drum vibratory roller at the end of each day of placement and prior to any significant precipitation event that may occur during the working day unless otherwise approved by the engineer. The purpose for compacting the exposed surface is to decrease the amount of infiltration into the CCB and to help minimize erosion of the CCB. Throughout the construction period the contractor shall grade the surface of the fill to prevent the ponding of surface water. The contractor is advised that all CCB materials are highly susceptible to pumping if excess water is present.

The CCB will be used to backfill the drained pits. It will not be possible to prevent the temporary ponding of water in these pits following precipitation events during the initial stages of the backfilling operations when the fill is being placed below the elevation of the surrounding grade. To the extent possible, the contractor shall place CCB materials in the pits during periods when the potential for rain is minimal. Coal ash is much better suited for below grade filling than Poz-O-Tec. If the pits are hydraulically connected to deep mine workings, coal ash (consisting of both fly ash and bottom ash) may, with the approval of the Engineer, be used to bridge through and backfill specific pits. Further, the filling operations shall be performed to minimize the size of the below-grade working area and by diverting surface water away from the active fill area to sump pits from which it can be continually pumped. The contractor may isolate the CCB from the potential for inundation in the pit by constructing diversion berms, isolation berms, dminage ditches, etc., at no additional cost to the STATE. In the event that a potion of the CCB fill becomes inundated in the pit during the placement operations, the contractor shall discharge the water in accordance with the Technical Specifications and allow the fill material to dry before proceeding with the filling operations in this area.

Since the CCB's are susceptible to erosion, the contractor shall bring portions of the fill to final grade as soon as possible. Areas that have reached final grade shall be covered with a minimum of 2 ft of the vegetative layer within 10 working days unless otherwise approved by the engineer.

As noted in Figure 3, the vegetative layer shall consist of a minimum of 2 ft of compacted minespoil overlain with 1 ft of uncompacted minespoil and/or natural soils. The compacted zone shall be placed in lifts and the surface compacted with evenly distributed passes of the construction equipment across the entire surface. The surface of the uncompacted layer shall be prepared and seeded in accordance with the Technical Specifications.

In areas where CCB will be present immediately beneath the vegetative layer, the surface of the CCB shall be benched as noted in Figure 4 prior to the placement of the vegetative layer.

The contractor shall maintain drainage through the work area while the CCB filling opemtions are in progress. To minimize the potential for significant erosion along these drainageways, the contractor shall cover the CCB exposed in the drainageways prior to any significant forecasted precipitation events. The cover shall consist of 1 ft of compacted minespoil, a geomembrane sheet placed over the CCB. or other method approved by the engineer. The placement of the cover shall be done in such a manner that it will not impede the flow of surface water within the dminageway or divert the flow away from the dminageway. The temporary graded surface within the drainageway shall provide a minimum of 2ft of flow depth and 2(H): l(V) sideslopes.

Figure 3. Vegetative Layer Detail

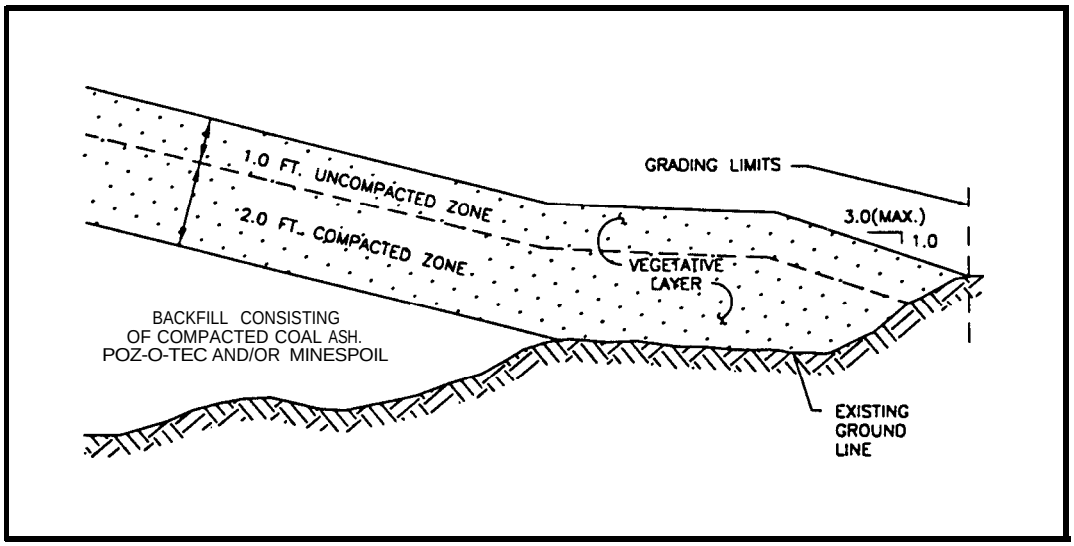
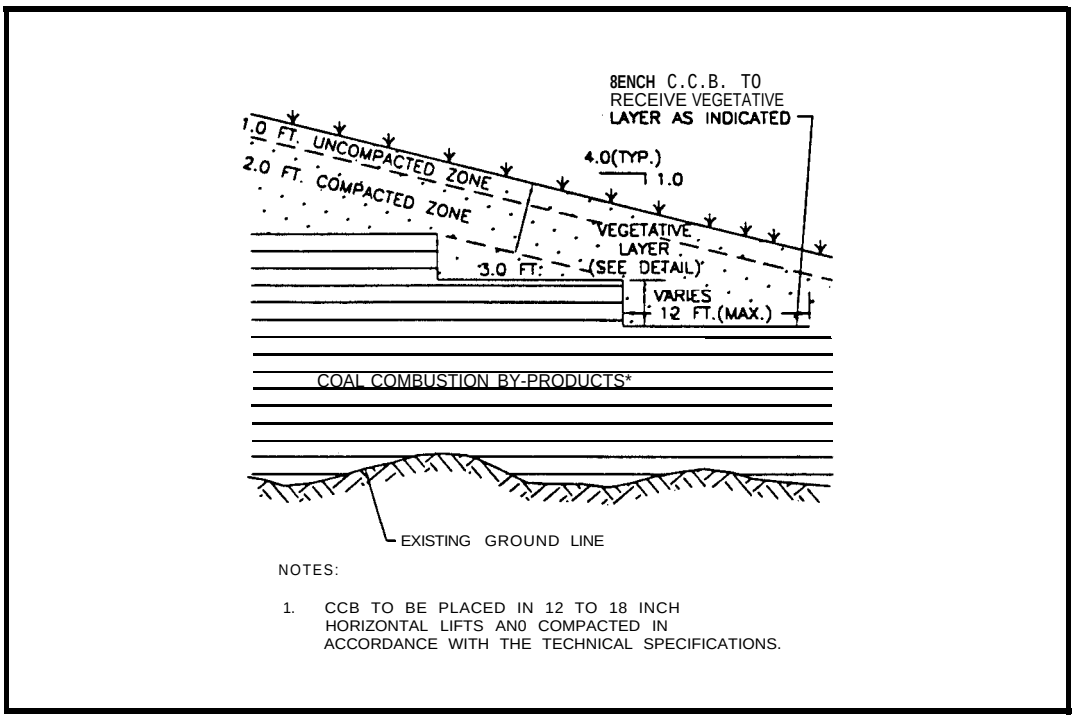


Figure 4. Typical CCB Placement Detail

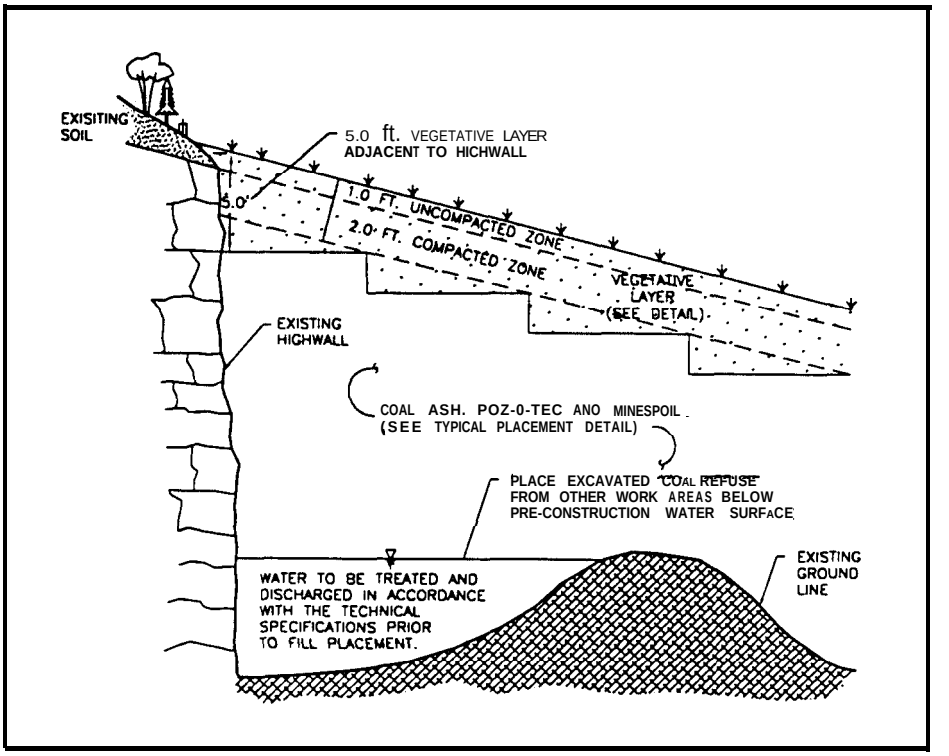


If minespoil is used as the cover, it Figures 3 & 4 can be left in-place as part of the grade-raise fill. If a geomembrane sheet is used as the cover, it must be anchored along the edges to prevent the flow of water beneath the sheet and to prevent it from being lifted in high winds. Further, once final grades have been completed along the drainageways, the contractor shall install the riprap lining within 10 working days unless otherwise approved by the engineer.

The drawings note the locations within the site where the CCB materials shall be placed. Fill placed within the area designated for Poz-O-TEC shall be limited to Poz-O-Tec minespoil unless otherwise approved by the engineer. Fii placed within the areas designated for coal ash may consist of coal ash, Poz-O-Tec and minespoil. In areas where the Poz-O-Tec limits overlap with the coal ash limits, the intent is to place the Poz-O-Tec over the coal ash to limit the infiltration of surface water into the fill.

The contractor shall take all necessary precautions to protect the equipment operators from rockfalls that could occur due to the construction activities in areas where CCB materials will be placed immediately adjacent to the highwalls. Further, it will be necessary to ensure that the fill materials placed next to the highwall are well compacted to minimize the potential for the formation of a crack between the highwall and the fill. Finally, the thickness of the vegetative layer shall be increased to 5 ft in the vicinity of the highwalls as noted in Figure 5 to minimize the potential for the infiltration of surface water into the zone between the fill and the highwall. The surface of the vegetative layer shall be blended and shaped into the existing ground surface to prevent the ponding of water along the interface of the highwall and the backfill.

Figure 5. Typical Highwall Backfill Detail



Conclusions

The utilization of CCB materials at the Midwestern Mine Site has significantly enhanced the reclamation plan by reducing theinfiltration of surface water through acid producing coal refuse, minimizing the infiltration of surface water into abandoned underground mines and providing a source of alkalinity which should further improve the quality of both the surface water and the ground water at this site. The utilization of these materials has also helped to minimize disturbance of surrounding vegetated mine spoil as well as unmined lands that would have otherwise been needed as a source of borrow soils. This beneficial use of the CCB materials also reduces the volume of the materials that would typically be placed in landfiis, thus resulting in cost savings to the utilities and their users.

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