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Coolside Waste Management Research
(Project No. DE-AC21-MC91MC28162)

Quarterly Report
July 1, 1993 to September 30, 1993

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COOLSIDE WASTE MANAGEMENT RESEARCH

Technical Progress Report

Contract No: DE-AC21-91-MC8162

Report Period: July 1, 1993 to July 31, 1993

Statement of Project Objectives

Produce sufficient information on the physical and chemical nature of Coolside waste to design and construct physically stable and environmentally safe landfills.

Summary of Progress for Period

Monitoring of swell continued on Coolside pilot plant run #2 and FBC ash remolded near 95% of standard maximum dry density and optimum moisture content. Swell tests also continued on non-hydrated FBC specimens as well as FBC pellets which were loosely placed in CBR molds. No significant deviations from previously reported patterns have been observed.

Field and laboratory leaching studies have shown that the Coolside materials display low initial permeabilities which rapidly decrease upon addition of water. Where leaching has occurred the leachates are initially very high in sodium and chloride ions (10,000's ppm), potassium and sulphate (1,000's ppm), with lesser concentrations of molybdenum, boron, aluminum (10's ppm), arsenic, selenium and vanadium (ppm) being detected. In some cases, concentrations were shown to rapidly decrease by an order of magnitude within a few pore volume changes.

Subtask 2.3 Geotechnical Characterization of the Waste

Swell Tests

Monitoring of swell continued on the following samples: Coolside pilot plant run #2 and FBC ash. Swell specimens for both materials were remolded near 95% of standard maximum dry density and optimum moisture content. The samples were remolded in CBR molds (6 inch diameter, 4.584 " height) and swell was monitored under the following conditions:

approximately 12.5 lb. surcharge, no age time
approximately 2.5 lb. surcharge, no age time
approximately 12.5 lb. surcharge, 7 days age time
approximately 2.5 lb. surcharge, 7 days age time

Time of aging represents the amount of time before the samples were placed in water. Aged specimens were sealed at room temperature to prevent moisture loss before placement into the water tank.

Swell tests were continued on non-hydrated FBC specimens remolded near 95% of standard density and optimum water content in CBR molds. Swell is being monitored with aging and surcharge conditions similar to those of hydrated FBC ash and Coolside #2.

Swell measurements also continued on FBC pellets. The pellets were loosely placed in CBR molds. Two samples are being monitored with surcharges of approximately 2.5 and 12.5 pounds. Results, to date, of swell tests are presented in Figures 1 - 4.

Figure 1. Swell Versus Time, Coolside Run #2 CBR Samples.

Figure 2. Swell Versus Time, FBC Ash CBR Samples.

Figure 3. Swell Versus Time, FBC Ash (Non-Hydrated) CBR Samples.

FBC Pellets

Figure 4. Swell Versus Time, FBC Pellets

Task 3 and 4. Field and Laboratory Leaching Studies

The elemental release from fly ash and dry flue gas desulfurization by-products are being examined by batch extractions, laboratory columns and field lysimeters. The Coolside materials display low initial permeabilities which rapidly decrease upon addition of water. Where leaching has occurred the leachates are initially very high in sodium and chloride ions (10,000's ppm), potassium and sulphate (1,000's ppm), with lesser concentrations of molybdenum, boron, aluminum (10's ppm), arsenic, selenium and vanadium (ppm) being detected. In some cases, concentrations were shown to rapidly decrease by an order of magnitude within a few pore volume changes.

The laboratory leaching studies are being done in 24" X 2" i.d. PVC columns. Samples of the materials were packed into the columns at three different packing densities; a) 69 lb/ft³ @ 36% moisture, b) 65 lb/ft³ @ 45% moisture and c) 49 lb/ft³ @ 41% moisture reflecting the densities that would be achieved using conventional heavy equipment in the field based applications. The columns were fitted with nylon ball valves which allowed a 1" head of water to be kept over each column. 70mL of deionized water was added to the top of each column weekly while 70 mL of leachate was drawn from the bottom of the column for metals analysis and leachate characterization.

Field concrete lysimeters measuring 8'X8'X10' were packed with Coolside materials at the same densities used in the laboratory studies. Lengths of slotted 4" PVC pipe was laid parallel to the packing plane at 3' intervals and passed through a knock-out plug in the inner wall of the lysimeter to a series of 40 liter Nalgene containers located in the central collection chamber. The field site is sampled twice a week for leachate collection as well as the measurement of bed temperature profiles from a series of thermocouples placed within each lysimeter. Moisture profiles of each lysimeter are also recorded twice weekly using a Troxler 4300 Depth Moisture Gauge. A fourth lysimeter at the field site is packed with a sample of commercially available fly ash to serve as a reference sample. The average annual rainfall for the field site is 48 inches.

Results

The leachates generated in the laboratory columns were found to be initially very high in sodium and chloride and total alkalinity (10,000's ppm) as well as containing significant levels of potassium, calcium and sulfates (1000's ppm) although concentrations were found to decrease rapidly after only a few pore volume changes. Of particular interest was the release of arsenic, initial levels were sub ppm, rapidly increasing to a maximum value of 6.3 ppm after 5 weeks of leaching, then gradually decreasing.

A comparison was also carried out on the effects of increased CO₂ levels on leaching profiles. A second column was simultaneously leached under an atmosphere of 2.5% CO₂ in air, representing typical CO₂ levels commonly found in the vadose zone. While the overall leaching profile was found to be similar to those observed for the column experiments run under air, the peak concentrations of metals forming oxy-anions, e.g. As, Se, Cr, Mn, V and B were found to be increased, often by a factor of up to 2.

Once the field lysimeters were exposed to natural rainfall, they exhibited characteristic hydration profiles as monitored by the depth moisture gauge. The fly ash, as expected, was found to have a high permeability and allowed moisture to rapidly pass through the bed whereupon hydration of the fly ash proceeded from the lower levels upwards. i.e. Rate of Hydration < < Percolation. The Coolside materials however exhibited very low permeability and underwent hydration from the upper levels in a downwards direction. i.e Rate of Hydration > > Percolation.

For the Coolside packed lysimeters, the initial percolation of rainfall into the lysimeters was followed by a rapid increase in bed temperature (an increase of 35°C for L-1). The observed temperature increases were larger than those calculated for the hydration of anhydride within the lysimeter and must be due to other exothermic mineralogical reactions occurring within the material. The magnitude of the temperature increase was also found to be inversely proportional to the bed packing density indicating that the reaction may be inhibited by dense packed beds

and is dependent upon large inter-particle void volumes to proceed.

Initial observations from the field lysimeters have shown that the leachate composition is similar to that obtained from the laboratory columns. i.e initially high in sodium, chloride, alkalinity, potassium, sulphate and calcium. Initial arsenic levels were found to be slightly higher than those observed from the laboratory columns (11 ppm as opposed to 6 ppm) and had not been shown to decrease in concentration after 8 weeks of sample collection.

Table 1 lists the average metal concentrations measured for leachates collected from both leaching systems to date. In addition the results of the TCLP analysis performed on a sample of Coolside material are included for comparative purposes. Comparing the values measured for each leaching system, it can be seen that mean metal concentrations differ at worst by one order of magnitude for each metal determined. Comparing the results of each leaching system with the results obtained by TCLP analysis however, it can be seen that for several metals, particularly arsenic, the mean metal concentrations measured vary by factors greater than 500. Indeed, several metals, e.g. Cu, Ni and Pb, measured in both the column and field lysimeter leachates were not even detected in the TCLP.

From the results in Table 1. initial observations would tend to suggest that the leachate generated from the laboratory column lysimeters is indeed representative in composition to leachate collected from the much larger field lysimeters, mean concentrations differing by less than one order of magnitude. In addition, it would appear that the Toxicity Characteristic Leaching Procedure (TCLP) is inapplicable to Coolside derived Flue Gas Desulfurization by-product materials particularly with respect to Arsenic, Molybdenum, Silicon and Vanadium release profiles where differences in mean metal concentrations differed by up to three orders of magnitude compared to the results obtained by column and field lysimeter leaching systems. When peak metal concentrations are used the differences between results obtained by the TCLP method and the other leaching procedures are found to be even greater.

In an investigation of the effect of headspace gas composition on elemental release profiles from

laboratory column lysimeters, it was found the relatively high levels of CO₂, similar to those measured in the vadose zone, resulted in increased leachate concentrations of metals forming oxy-anions, such as arsenic, vanadium, molybdenum, selenium and chromium. The mechanism of release involving CO₂ overpressure is not known as of yet and is remains the subject of further investigation.

**Table 1. Average Metal Concentration Measured in Leachate Generated
from Different Leaching Systems
(Concentration in ppm)**

	Column ⁽²⁾		Lys. ⁽³⁾	Ash	TCLP	Column/Lys	Column/TCLP	Lys./TCLP
Ash/TCLP								
Al	16.10	14.80	1.23		1.09	(1)	(1)	(1)
As	1.67	9.12	0.53	0.01	0.18	119.21	651.16	38.13
B	4.86	1.16	101.00		4.18	(1)	(1)	(1)
Ba	0.104	0.005	0.020	0.235	20.78	0.44	0.02	0.09
Be	0.000	0.001	0.001		0.29	(1)	(1)	(1)
Ca	32.84	23.2	348	2700	1.42	0.01	0.01	0.13
Cd	0.001	0.001	0.001		1.05	(1)	(1)	(1)
Co	0.005	0.010	0.010		0.50	(1)	(1)	(1)
Cr	0.004	0.005	0.606	0.004	0.76	0.95	1.25	151.46
Cu	0.004	0.083	0.016		0.05	(1)	(1)	(1)
Fe	0.037	0.016	0.005	0.192	2.40	0.19	0.08	0.03
K	1341	2025	1310	36.0	0.7	37.3	56.3	36.4
Mg	0.076	0.020	10.92	0.270	3.81	0.28	0.07	40.45
Mn	0.007	0.016	0.005		0.46	(1)	(1)	(1)
Mo	7.47	14.55	49.19	0.35	0.51	21.17	41.22	139.35
Na	4433	6188	701	685	0.72	6.47	9.03	1.02
Ni	0.008	0.010	0.010		0.75	(1)	(1)	(1)
P	0.050	0.204	0.013		0.25	(1)	(1)	(1)
Pb	0.021	0.020	0.048		1.03	(1)	(1)	(1)
Se	0.607	1.538	0.031	0.204	0.39	2.97	7.54	0.15
Si	41.85	42.00	0.96	0.71	1.00	58.94	59.15	1.35
Ti	0.003	0.012	0.022	0.100	0.27	0.03	0.12	0.22
V	0.68	1.44	0.35	0.00	0.47	225.5	480.4	117.7
Zn	0.162	0.004	0.002	0.005	39.21	32.35	0.83	0.40

(1) Not Detected in TCLP Analysis.

(2) Data from 22 weeks of leachate collection

(3) Data from 9 weeks of sample collection

COOLSIDE WASTE MANAGEMENT RESEARCH

Technical Progress Report

Contract No: DE-AC21-91-MC8162

Report Period: August 1, 1993 to August 31, 1993

Statement of Project Objectives

Produce sufficient information on the physical and chemical nature of Coolside waste to design and construct physically stable and environmentally safe landfills.

Summary of Progress for Period

Monitoring of swell continued on Coolside pilot plant run #2 and FBC ash remolded near 95% of standard maximum dry density and optimum moisture content. Swelling of a sample which had been soaking in water for 220 days was observed at 32%. Swell tests continued on non-hydrated FBC specimens as well as FBC pellets which were loosely placed in CBR molds. No significant deviations from previously reported patterns have been observed.

Permeability and unconfined compressive strength tests were performed on cored samples taken from the field lysimeters #1, 2 and 4. The moisture contents of samples taken from the three lysimeters were determined. Lysimeter #1 contained 86.3% moisture versus the initial content of 37%, lysimeter #2 contained 79.0% versus an initial 40%, and lysimeter #3 contained 63.6% moisture versus an initial 37%. Standard penetration tests were performed on samples from lysimeters #2 and #3. In the penetration tests the blow counts for the sample from lysimeter #3 were significantly higher than for #2. Mineral analyses are being conducted on these samples. An inplace CBR value performed on the surface of the material in lysimeter #3 was 125% .

An unconfined compressive strength measurement on a hydrated FBC ash specimen molded near 95% maximum dry density has shown a sharp increase in strength over a 96 days period. The reading at the end of this period was 703 psi.

Monitoring data on the field lysimeters in Montgomery county, KY is presented. Temperature and bed moisture values are taken twice weekly. The lysimeter temperatures increased as soil temperatures increased over the summer months. The higher temperatures of the top and middle thermocouples in Lysimeter 3 indicated a continuation of the exothermic reaction that commenced upon the hydration of the materials prior to emplacement. It is possible that insufficient water was added during the packing period to drive the exothermic reactions to completion.

Overall moisture levels remained fairly uniform over the period due to the relatively uniform rainfall which fell over the summer months. The leachate pH values for Lysimeters 1 and 2 are significantly lower than those measured from Lysimeter 3 and have remained consistent at a $\text{pH} \approx 9.0$ compared to a pH of ≈ 12.2 measured from Lysimeter 3. This effected the observed metal release profiles from Lysimeters 1 and 2. Likewise the alkalinity levels are lower for cells 1 and 2 while the alkalinity values measured for L3 decreased steadily over the monitoring period indicating that the buffering system holding the pH at ≈ 12.2 is near exhaustion and that the leachate pH should fall rapidly to a lower value in the near future. Total conductivity measurements are much higher than for L 3 indicating a higher ionic content in the leachate samples from these cells.

Arsenic levels measured in the leachates from Lysimeters 1 and 2 are lower than those measured in L 3 and are indicative of the lower pH values. The solubility of the arsenate anion decreases with pH , and as a result the levels measured in L3 with a pH of 12.2 are significantly higher than those measured from L1 and L2. The levels of sodium samples from Lysimeters 1 and 2 are higher than those observed from L3 which is consistent with the higher conductivities measured for these samples. The sulphate levels observed in the leachate from cells 1 and 2 are also significantly higher than those measured in L3 and are most likely due to the lack of formation of mineralogic species at the lower pH values.

Subtask 2.3 Geotechnical Characterization of the Waste

Swell Tests

Monitoring of swell continued on the following samples: Coolside pilot plant run #2 and FBC hydrated and non-hydrated ash. Swell specimens for both materials were remolded near 95% of standard maximum dry density and optimum moisture content. The samples were remolded in CBR molds (6 inch diameter, 4.584 " height) and swell was monitored under the following conditions:

- approximately 12.5 lb. surcharge, no age time
- approximately 2.5 lb. surcharge, no age time
- approximately 12.5 lb. surcharge, 7 days age time
- approximately 2.5 lb. surcharge, 7 days age time

Time of aging represents the amount of time before the samples were placed in water. Aged specimens were sealed at room temperature to prevent moisture loss before placement into the water tank.

A CBR test was performed on a Coolside pilot plant sample which had been soaking in water for a period of 220 days. Total swell was 1.459 inches (31.82 %) in that time period. The CBR value of the specimen was 6. Values of CBR obtained from other Coolside pilot plant run #2 samples subjected to long term swell are compared in Table1.

Table 1. Results from CBR and Swell Tests, Coolside Run #2

Age Time (days)	Surcharge Weight (lbs.)	Soaking Time (days)	CBR (%)	Total Swell (inches)	Percent Swell
0	12.50	116	36.3	0.701	15.29
0	2.50	220	6.0	1.459	31.82
7	2.50	100	50.0	0.300	6.54
7	12.50	99	143.8	.210	4.58

Swell testing continued on non-hydrated FBC specimens remolded near 95% of standard density and optimum water content in CBR molds. Swell is being monitored with aging and surcharge conditions similar to those of hydrated FBC ash and Coolside #2.

Swell measurements also continued on FBC pellets. The pellets were loosely placed in CBR molds. Two samples are being monitored with surcharges of approximately 2.5 and 12.5 pounds. Results, to date, of swell tests are presented in Figures 1 - 4.

Field Lysimeters

Samples were obtained from the field lysimeters using a truck mounted drill rig and a portable pavement coring machine. Permeability and unconfined compressive strength tests were performed on thin-walled, "undisturbed" (2.80 in. diameter) specimens obtained from lysimeter numbers 1, 2, and 4. Standard penetration tests were performed and samples (1.375 in. diameter) were obtained from the tests in lysimeters 2 and 3 because the Coolside materials were too stiff to obtain thin-walled samples except for one sample about 6 in. in length was obtained from lysimeter #2. The standard penetration test samples and portions of the thin-walled tube samples were submitted to the Center for Applied Energy Research to determine if any mineral changes have occurred since placement in the lysimeters. Standard penetration testing consist of driving a 2 in. O.D. sampler into the soil a distance of 18 in. with a 140 lb. weight free falling a distance of 30 in. The number of blows required to drive the sampler is recorded in three six inch increments. Blow counts have been correlated and can be used to estimate some engineering properties (strength, bearing capacity, etc). Blow counts for lysimeters 2 and 3 are:

Lysimeter	Depth	N (Blow Counts)
2	2.0' - 3.5'	7 - 13 - 18
2	2.0' - 3.5'	8 - 16 - 19
3	2.0' - 3.0'	32 - 85

A portable pavement coring apparatus was used in an attempt to obtain 2 in. diameter core samples of the Coolside materials in lysimeters 2 and 3. A small area (approximately 2 ft. by 3 ft.) of the top two ft. of overburden soil was removed and the coring machine placed directly on the Coolside material. Compressed air was used in place of water to keep the bit cool, remove cuttings, and to prevent external water from entering the lysimeters. The samples fractured along horizontal planes while coring therefore, they were not suitable for testing.

An in place CBR test was performed on the surface of Coolside material in lysimeter #3. The test was performed using a field CBR jack attached to the truck mounted drill rig. The CBR value at the surface of lysimeter #3 which was compacted near ninety five percent of maximum standard dry density was 125%. The moisture content of the material at the location of the test was 63.61 %.

Permeability and unconfined compressive strength were performed on thin-walled samples obtained from the field lysimeters. Test results are presented in Table 2. Moisture contents of five samples from lysimeter 1 (filled with no compactive effort was 86.34%). the material was placed at approximately 37 % moisture content. The moisture content from one sample in lysimeter 2 was 78.97%. Coolside material was placed in this lysimeter near 40 %. The moisture content obtained from the CBR test performed on material in lysimeter 3 was 63.61%. The material was compacted close to 37% moisture content initially.

Table 2. Results of Lysimeter Permeability and Unconfined Compressive Strength Tests

Lysimeter and Sample Depth	Coefficient of Permeability (cm/sec)	Field Moisture Content (%)	Field Dry Density (lbs/ft ³)	Unconfined Compressive Strength	Unconfined Compressive Strength
L-1 2.0-2.5	3.65×10^{-5}	91.70	33.82		6.31
L-1 3.5-4.0	9.76×10^{-4}	88.13	38.80		2.60
L-1 2.5-3.0		80.24	37.34	2.60	
L-1 2.7-3.3		79.72	43.39	6.82	
L-1 3.0-3.5		92.89	36.63	10.01	
L-2 2.0-2.5	2.85×10^{-4}	78.97	44.90		
L-4 2.0-2.5		28.56	76.46	4.97	
L-4 2.5-3.0	6.08×10^{-5}	34.75	71.90		

Unconfined Compressive Strength Tests

An unconfined compressive strength test was performed on a FBC ash (hydrated) specimen remolded near ninety-five percent of maximum dry density and standard moisture content. The specimen was sealed and aged 96 days before testing. The unconfined compressive strength of the sample was 703.02 psi. Unconfined strength is shown in Figure 5 with strengths previously obtained from specimens aged at varying times.

Task 3. Field Leaching Studies

Monitoring of the field lysimeters in Montgomery county, KY is continuing. The field site is visited twice weekly when temperature and bed moisture values are recorded. In addition, samples of leachate are collected, if present and analyzed for composition.

Bed Temperature.

The lysimeter temperatures continued to increase as overall soil temperatures in the region increased over the summer months. (Figs 6, 8, 10, 12) The top and middle thermocouples in Lysimeter 3 (Fig. 10) showed a higher than background temperature increase and most likely indicates a continuation of the exothermic reaction that commenced upon the hydration of the materials prior to emplacement. Lysimeter 3 contains the densest packed bed and hence the most material, it is possible that insufficient water was added during the packing period to drive the exothermic reactions to completion.

Bed Moisture.

Overall moisture levels remained fairly uniform over the period measured due to the relatively uniform rainfall which fell over the summer months as shown in Figures 7, 9, 11, and 13. Lysimeters 1 and 2 started to produce leachate in late June, compositional data is included in this report.

pH

The leachate pH values measured from Lysimeters 1 and 2 are significantly lower than those measured from Lysimeter 3 (Figs 14, 15, 16) and have remained consistent at a $\text{pH} \approx 9.0$ over the observed period compared to a pH of ≈ 12.2 measured from Lysimeter 3. This lower pH has had a significant effect of the observed metal release profiles from Lysimeters 1 and 2.

Alkalinity

In addition to the observed differences in leachate pH measured from each Coolside lysimeter,

total alkalinity levels are also lower for cells 1 and 2. (≈ 200 mg/l c.f. 2000 mg/l for Lysimeter 3) (Figs 17, 18, 19)

The alkalinity values measured for L3 have decreased steadily over the monitoring period, i.e. down to 2000 ppm from 8000 ppm at the start of leachate collection, indicating that the buffering system holding the pH at ≈ 12.2 is near exhaustion and that the leachate pH should fall rapidly to a lower value in the near future.

Conductivity

For Lysimeters 1 and 2, total conductivity measurements are much higher than for L 3 indicating a higher ionic content in the leachate samples from these cells. (Figs 20, 21, 22)

Arsenic.

The arsenic levels measured in the leachates collected from Lysimeters 1 and 2 are an order of magnitude lower than those measured in L 3 (Figs 23, 24, 25) and are indicative of the lower pH values measured for these samples. The solubility of the arsenate anion decreases with pH, and as a result the levels measured in L3 with a pH of 12.2 are significantly higher than those measured from L1 and L2.

Sodium.

The levels of sodium measured in samples of leachate from Lysimeters 1 and 2 are much higher than those observed from L3 (Figs 26, 27, 28). This is consistent with the higher conductivities measured for these samples. The solubility of sodium within this system is obviously increased at lower pH's and may be attributed to the lack of formation of mineralogic species observed in the Coolside materials at high pH values.

Sulphate.

The sulphate levels observed in the leachate from cells 1 and 2 are also significantly higher than those measured in L3 (Figs 29, 30, 31) and are also most likely due to the lack of formation of mineralogic species at the lower pH values existing in Lysimeters 1 and 2.

Work Planned For Next Month

Monitoring of swell will continue on FBC ash samples and pellets. Classification tests will be performed on Coolside samples obtained from the field lysimeters. Permeability tests will be performed on lysimeter overburden samples.

Two papers will be presented at the Tenth Pittsburgh Coal Conference; "Techniques used to Place Coolside By-Product in Field Lysimeters" and "Swelling Characteristics of Coolside and FBC By-Products". One poster presentation will also be made at the conference; "A Proposed Procedure to Compact Samples for Physical Properties Testing".

Coolside Run #2

CBR Samples

Figure 1. Swell Versus Time, Coolside Run #2 CBR Samples.

Figure 2. Swell Versus Time, FBC Ash CBR Samples.

Figure 3. Swell Versus Time, FBC Ash (Non-Hydrated) CBR Samples.

FBC Pellets

Figure 4. Swell Versus Time, FBC Pellets

FBC Ash

Hydrated

Figure 5. Unconfined Compressive Strength versus Time, FBC Ash (hydrated)

Lysimeter 1 Temperature Profile Coolside :- Static Density

Figure 6

Moisture Profile : Lysimeter 1 Neutron Probe Readings

▽ 0.5 × 2.5 + 4.5 ⊙ 6.5 ■ 8.5

Figure 7

Lysimeter 2 Temperature Profile Coolside :- Low Energy Density

Figure 9

Lysimeter 3 Temperature Profile Coolside :- Standard Density

Figure 10

Figure 11

Lysimeter 4 Temperature Profile Fly Ash :- Low Energy Density

Figure 12

Figure 13

Lysimeter 1 Release Profiles pH

Figure 14

Lysimeter 2 Release Profiles pH

Figure 15

Figure 16

Figure 17

Lysimeter 2 Release Profiles Alkalinity

Figure 18

Figure 19

Lysimeter 1 Release Profiles Conductivity

Figure 20

Lysimeter 2 Release Profiles Conductivity

Figure 21

Figure 22

Lysimeter 1 Release Profiles Arsenic Release

Figure 23

Lysimeter 2 Release Profiles Arsenic Release

Figure 24

Lysimeter 3 Release Profiles Arsenic Release

Figure 25

Figure 26

Figure 27

Figure 28

Lysimeter 1 Release Profiles Sulphate Release

Figure 29

Figure 30

Figure 31

COOLSIDE WASTE MANAGEMENT RESEARCH

Technical Progress Report

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Report Period: September 1, 1993 to September 30, 1993

Statement of Project Objectives

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Summary of Progress for Period

Monitoring of swell continued on both hydrated and nonhydrated FBC ash remolded near 95% of standard maximum dry density and optimum moisture content and FBC pellets. Swelling of 7-day aged hydrated (260 days) and non-hydrated (< 160 days) samples for both 2.5 lb and 12.5 lb surcharges continue to be less than for unaged samples. The magnitude of swelling in the hydrated samples after 100 days is significantly less than in the non-hydrated samples. Swell tests continued on non-hydrated FBC specimens as well as FBC pellets which were loosely placed in CBR molds. No significant deviations have occurred from previously reported patterns.

Permeability and unconfined compressive strength tests on remolded Coolside specimens after aging 375 days are reported for samples compacted at 90, 95 and 100% levels at low energy, standard and modified dry densities. Compressive strengths increase with the density samples for three different compaction levels. Permeabilities of similarly prepared low density samples after 200 days aging were higher than the corresponding densities for the two compaction levels with the magnitude of the 90% compaction samples being much greater in magnitude. The unconfined compressive strengths after permeation of these low density samples were significantly less than for the other densities for all compaction levels. The magnitudes did not differ significantly between compaction levels.

Subtask 2.3 Geotechnical Characterization of the Waste

Swell Tests

Monitoring of swell continued on the following samples: FBC ash (hydrated and non-hydrated). Swell specimens for both materials were remolded near 95% of standard maximum dry density and optimum moisture content. The samples were remolded in CBR molds (6 inch diameter, 4.584 " height) and swell was monitored under the following conditions:

- approximately 12.5 lb. surcharge, no age time
- approximately 2.5 lb. surcharge, no age time
- approximately 12.5 lb. surcharge, 7 days age time
- approximately 2.5 lb. surcharge, 7 days age time

Time of aging represents the amount of time before the samples were placed in water. Aged specimens were sealed at room temperature to prevent moisture loss before placement into the water tank.

Swell measurements continued on FBC pellets. The pellets were loosely placed in CBR molds. Two samples are being monitored with surcharges of approximately 2.5 and 12.5 pounds. Results, to date, of swell tests are presented in Figures 1 - 3.

Unconfined Compressive Strength

Unconfined compressive strength tests were performed on remolded Coolside specimens. Tests were performed on several specimens remolded near ninety, ninety five, and one hundred percent of low energy, standard, and modified dry densities and the corresponding optimum moisture content. The tests were performed on specimens sealed and aged for various times at room temperature. These tests have been performed over the past few months. Results are presented in Figures 4 through 6 with data previously obtained.

Permeability

Permeability tests were performed on remolded specimens. These specimens were remolded at

densities and moisture contents similar to unconfined compressive strength specimens. Permeability test results are presented in Figures 7 through 9.

Unconfined compressive strength tests were performed on the samples after permeability tests were completed. Determining the unconfined compressive strength after testing for permeability shows the strength of the specimens in a saturated, or almost saturated condition. Results of unconfined compressive strength tests performed after permeability testing are shown in Figures 10 through 12.

Activities

Seven papers were presented and published in the Proceedings of the *Tenth Annual Pittsburgh International Coal Conference* September 21 - 24, 1993.

- Beckham, T. L.; Hopkins, T. C. *Techniques Used in Placement of Coolside By-Products in Field Lysimeters*, p. 173.
- Hopkins, T. C.; Beckham, T. L. *A Proposed Procedure for Compacting Laboratory Specimens for Physical Properties Testing*, p. 204.
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Work Planned For Next Month

Monitoring of swell will continue on FBC ash and FBC pellets. Testing will begin on synthetic aggregate supplied by Consol for use in bituminous concrete.

Figure 1. Swell Versus Time, FBC Ash CBR Samples.

Figure 2. Swell Versus Time, FBC Ash (Non-Hydrated) CBR Samples.

FBC Pellets

Figure 3. Swell Versus Time, FBC Pellets

UNCONFINED COMPRESSIVE STRENGTH

90% Compaction

Figure 4. Unconfined Compressive Strength vs Time, 90% Compaction

UNCONFINED COMPRESSIVE STRENGTH

95% Compaction

Figure 5. Unconfined Compressive Strength vs Time, 95% Compaction

UNCONFINED COMPRESSIVE STRENGTH

100% Compaction

Figure 6. Unconfined Compressive Strength vs Time, 100% Compaction

Figure 7. Permeability vs Time, 90% Compaction

UNCONFINED COMPRESSIVE STRENGTH

95% Compaction

Figure 8. Permeability vs Time, 95% Compaction

Figure 9. Permeability vs Time, 100% Compaction

UNCONFINED STRENGTH AFTER PERMEABILITY

90% Compaction

Figure 10. Unconfined Compressive Strength After Permeability vs Time, 90% Compaction

UNCONFINED STRENGTH AFTER PERMEABILITY

100% Compaction

Figure 12. Unconfined Compressive Strength After Permeability vs Time, 100% Compaction

Figure 11. Unconfined Compressive Strength After Permeability vs Time, 95% Compaction

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