Leachate Characteristics of Fly Ash Stabilized with Lime Sludge

M.A. GABR, ELLIS M. BOURY, AND JOHN J. BOWDERS

Development of a particulate permeation grout consisting of fly ash and acid mine drainage (AMD) treatment sludge was investigated. Results indicated that a mix consisting of 50 percent AMD sludge solids and 50 percent fly ash had the best characteristics with regard to flow reduction and pozzolan content. The measured hydraulic conductivity of the grout increased with increasing fly ash content and was on the order of 2 × 10^{-5} to 7 × 10^{5} cm/sec. Effluent analysis indicated total alkalinity values, measured as $CaCO_3$, in the range of 12 to 97 mg/L. Total iron and manganese were typically less than 1 mg/L for the remainder of the test period for all grout mix ratios. The aluminum concentration ranged from 1 to 1.8 mg/L and began to rise slowly as the testing proceeded. The highest value reached was between 3.6 and 4.0. The increases in aluminum concentrations closely followed the noted increases in alkalinity and pH. Results from bench scale testing indicated that grouting provided one to two orders of magnitude reduction in the hydraulic conductivity. This reduction was achieved by grouting 59 to 64 percent of the voids. Effluent analysis from the bench scale testing indicated a pH of 8.6 to 8.9 and iron, manganese, and aluminum of less than 1 mg/L for all samples collected during the testing period of approximately 2 months.

Currently, only 20 to 25 percent of approximately 50 million tons of fly ash generated each year is used (*1*). The remainder is disposed of mainly in landfills and slurry ponds (*2*). At the same time, the disposal of sludge generated from the treatment of the acid mine drainage (AMD) generated from the coalfields of the eastern and midwestern United States presents another waste management challenge. The treatment of mine water entails the addition of chemical agents, which produces large quantities of chemical floc in the form of sludge. Common chemicals added include calcium hydroxide, calcium oxide, sodium hydroxide, sodium carbonate, and ammonia (*3,4*). On-site treatment of AMD with calcium oxide produces an abundant supply of sludge with potentially desirable characteristics. The sludge contains some fraction of unreacted lime, which can act as a catalyst to enhance the pozzolonic reactions in fly ash material. The need to develop new uses for fly ash and to dispose of the AMD sludge provides a strong impetus to investigate the use of both, in combination, to develop economical and effective grouts for highway applications where mass use is possible. A mix of fly ash and AMD sludge can be used to develop particulate permeation grouts for filling interstitial voids and fissures in rock or soil. In highway applications, permeation grouting is commonly used to control seepage in granular soils and fractured rock, control seepage in excavations, increase the bearing capacity of granular soils and shattered rock, improve slope stability, and strengthen brick and masonry structures (*5*).

The leachate characteristics and hydraulic conductivity of particulate grouts consisting of fly ash and AMD treatment sludge are investigated. The grout mixes were comprised of Class F fly ash collected from a single source and sludge generated by treatment of AMD with calcium oxide (quicklime). Five mixes were studied using leaching columns 100 mm in diameter. An optimum mix ratio was determined by examining the hydraulic conductivity and leachate characteristics of the various mixes. A bench scale testing program was conducted using the optimum mix from the column testing phase. The bench scale testing was performed using columns 0.27 m in diameter and mine spoil with grain sizes ranging from 0.3 to 30 mm. Leachate analyses included pH, total alkalinity, total acidity, total iron, manganese, and aluminum. The feasibility of forming grout material using fly ash and AMD sludge material is presented and discussed.

FLY ASH IN GROUT MIXES

Past investigations to evaluate use of fly ash to develop low permeability grouts were conducted, among others, by Hamric (*6*), Sharma (*7*), Almes (*8*), Harshberger (*9*), and Baker (*10*). These studies mainly used Class F fly ash and included stabilization with portland cement, lime; and amending agents, such as sand and clay.

Sharma investigated the use of fly ash grouts for mine subsidence control (*7*). Fly-ash-based grouts with differing proportions of portland cement were tested in the laboratory using rigid-wall, double-ring permeameters and flexible-wall permeameters. Results indicated that a fly ash grout stabilized with 8.5 percent portland cement produced the lowest hydraulic conductivity with a value between 4 10^{-7} and 9 × 10^{-7} cm/sec. Higher values were found for grouts with only 4 percent portland cement. Hydraulic conductivity values ranged from 4 × 10^{-5} cm/sec to 2 × 10^{-6} cm/sec in those grouts. Eftelioglu and Bowders (*11*) also investigated the hydraulic conductivity of fly ash-cement grouts. They reported a minimum hydraulic conductivity of 8.7 × 10^{-7} cm/sec for a grout mix containing 8.5 percent of portland cement. The hydraulic conductivity increased to 3.5 × 10^{-6} cm/sec as the weight percentage of cement was reduced to 3 percent.

Harshberger tested 26 grout mixes in a laboratory column study (*9*). Parameters of interest were hydraulic conductivity of the grouts and effluent analysis. Stabilizing agents included fluidized bed combustion ash, scrubber sludge (with and without the stabilizer, calcilox), hydrated lime, Type I portland cement, and bentonite and kaolinite clay. Results indicated that the fly ash and portland cement grout mixture produced the lowest hydraulic conductivity with a value of 5.0 × 10^{-6} cm/sec.

Depending on the stabilizing agent, two mechanisms usually exert control over decreasing hydraulic conductivities of fly-ash-based grouts. Lime and cement additions rely on the pozzolanic activity of the fly ash to produce a hardened mass. Hydration prod-

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M.A. Gabr and E.M. Boury, Department of Civil Engineering, West Virginia University, Morgantown, W.Va. 26506-6101. J.J. Bowders, Department of Civil Engineering, University of Texas, Austin, Tex. 78712-1076.

TABLE 1 Grout Mix Ratios and Physical Properties

Column No	Mix Ratio (% Sludge:% Fly Ash) (dry basis)	Dry Unit Weight (pcf)	Specific Gravity (G_s)	Porosity (n)	Void Volume (cm^3)
1	90 : 10	9.80	2.39	0.936	1727.82
2	70 : 30	12.31	2.42	0.925	1866.07
3	50 : 50	15.91	2.44	0.902	1903.47
4	30 : 70	21.96	2.47	0.861	2122.28
6	10 : 90	40.51	2.50	0.742	2905.15

ucts formed during curing tend to reduce the pore size within the stabilized matrix. On the other hand, amending agents, such as sand and clay, improve the grain size distribution, thus allowing a greater degree of compaction, decreasing pore size, and providing more tortuous flow paths. Clay particles within the amended mixtures may also swell during hydration, which decreases pore size. Compacted stabilized fly ash mixtures have produced hydraulic conductivity values as low as 10^{-7} cm/sec in the laboratory (*10*).

FLY ASH AND AMD SLUDGE GROUT DEVELOPMENT

Morphologically, most fly ash is made up of thin-walled glassy spheres, which can either be hollow (cenospheres), filled with small solid spheres (plerospheres), or filled with crystals. The remaining fraction is comprised of irregularly shaped particles (*2*). The chemical composition of fly ash includes a number of inert mineral

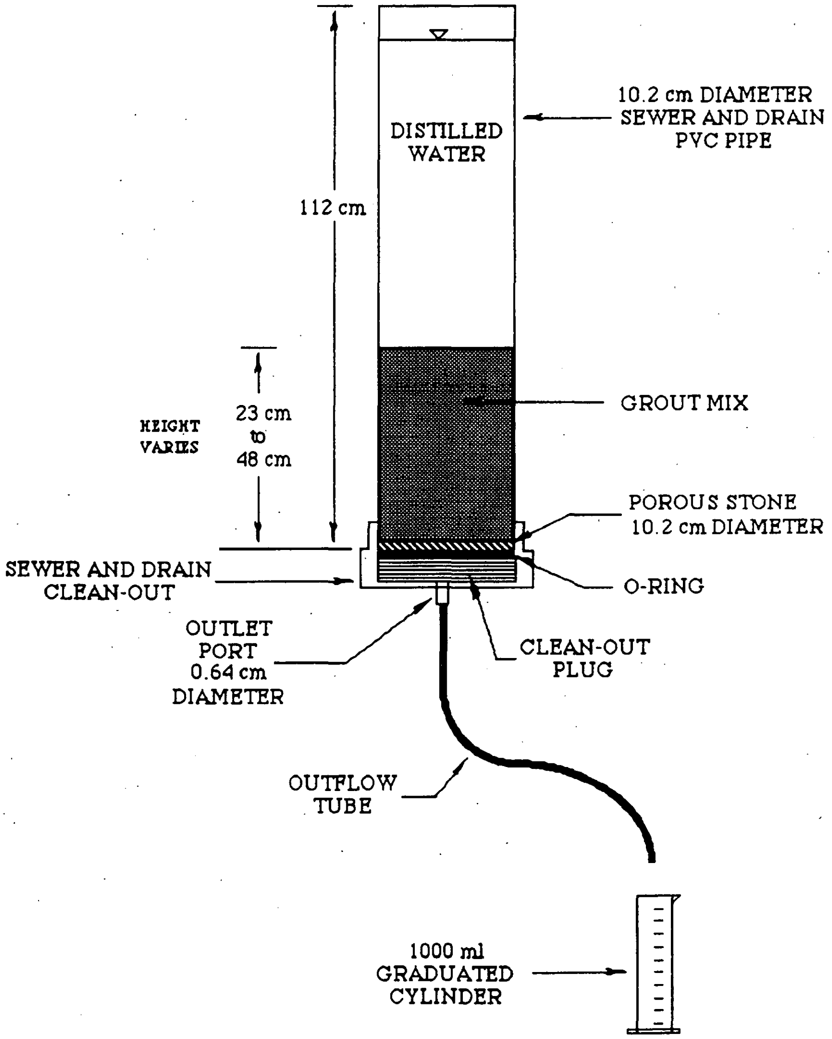

FIGURE 1 Column configuration used for grout development.

oxides, alkalies, and a small portion of trace elements. Hydraulic conductivities of compacted fly ash have been reported to range from 10^{-4} to 10^{-7} cm/sec (*12*).

Class F fly ash used in this study and obtained from the Hatfield power station in Pennsylvania was a low-calcium (1 to 2 percent CaO) ash with no appreciable self-hardening characteristics. The range and type of oxide composition of the fly ash include 45 to 50 percent SiO_2, 22 to 28 percent Al_2O_3, 14 to 22 percent Fe_2O_3, 1.2 to 1.4 percent CaO, 1 to 1.2 percent MgO, and 1.2 to 1.4 SO_3. The specific gravity of Class F fly ash was between 2.3 and 2.6 with a mean value of 2.4. Typically, the fly ash particles ranged in size from 5 to 100 microns in diameter, and 91 percent of the material passed a No. 200 sieve (0.074 mm).

The AMD sludge used in this study was generated by alkaline contact of AMD with quicklime (CaO) and was collected from an active AMD site. The total suspended solids (TSS) of the sludge material was approximately 32 g/L. The physical and chemical characteristics of AMD treatment sludge are highly variable and depend on the quality and quantity of AMD being treated, chemicals used for treatment, contact time, mixing, availability of oxygen, and sludge age as well as numerous other factors (*4*). The precipitate that makes up the sludge generally contains hydrated ferrous or ferric oxides, gypsum, hydrated aluminum oxide, and calcium carbonate and bicarbonate, with trace amounts of silica, phosphate, manganese, copper, and zinc (*4*).

Specimen Preparation and Testing

Five grout mixes were tested to determine their hydraulic conductivity and effluent characteristics. Mix proportions and grout physical properties are presented in Table 1. All grout mixtures were tested in 100-mm-inside-diameter and 1118-mm-long columns (Figure 1). Standard No. 4 filter paper was placed on top of the porous stone to limit the possibility of clogging the stone with fines. Mix ratios were based on the relative percentages of fly ash and sludge solids as determined by TSS. The sludge solids is the dry weight of solids as found using the TSS analysis procedure (*13*).

The amount of sludge was held constant for all mix ratios and the appropriate amount of fly ash was added to make the desired mix. This procedure resulted in grout samples between 229 and 482 mm high. Distilled water was used to keep the grout specimens submerged.

Hydraulic Conductivity

The hydraulic conductivity of five grout mix ratios was evaluated using the rigid-wall, falling-head method. Distilled water was used as the permeant fluid, and outflow from the columns was measured with time. The initial set of grout columns was permeated continuously for 58 days. In all cases, the hydraulic conductivity reached a steady value within the first five pore volumes of flow. Temperatures were recorded whenever test measurements were obtained. Hydraulic conductivity values have been adjusted to reflect the viscosity of water at 20°C. Table 2 summarizes the hydraulic conductivity measurements for all grout trials. The hydraulic conductivity for the grout mixes varied from 2×10^{-5} to 7×10^{-5} cm/sec. Values for a mix of 100 percent fly ash and a mix of 100 percent sludge were measured to be 2×10^{-3} cm/sec and 2×10^{-5}, respectively.

Results indicated that as the percentage of fly ash increased, the hydraulic conductivity also increased (Table 2). To compare the hydraulic conductivity values of the different mixes, a ratio of the hydraulic conductivity of the mix to the hydraulic conductivity of the 50:50 mix was used. These ratios are also presented in Table 2. The ratios for the 90:10 and 70:30 mixes are slightly greater than 1.0, which indicated that a slight difference in the hydraulic conductivity values existed. This ratio increased as the fly ash content reached 70 percent, and it approached 2.46 when the fly ash content reached 90 percent.

The 100 percent sludge mix resulted in a ratio of 0.87. This indicated that the hydraulic conductivity of the sludge alone is similar to the values of mixes that contain up to 50 percent fly ash content. However, using the hydraulic conductivity for the 100 percent fly ash content resulted in a ratio of 91.6. This indicated a hydraulic conductivity that is nearly two orders of magnitude higher than that of the 50:50 mix. Consequently, as the fly ash content reached the 70 percent level, the hydraulic conductivity characteristics of the fly ash began to dominate the flow pattern. This influence became more pronounced as the fly ash content continued to increase until the

TABLE 2 Average Hydraulic Conductivity Values for All Grouts

Column No	Trial Number	Mix Ratio (% Sludge:% Fly Ash) (dry basis)	Hydraulic Conductivity (Steady-State Average) (cm/s)	Ratio $k_x / k_{50:50}$
1	1	90 : 10	2.47×10^{-5}	1.09
2	1	70 : 30	2.62×10^{-5}	1.15
3	1	50 : 50	2.86×10^{-5}	1
4	1	30 : 70	3.69×10^{-5}	1.63
6	1	10 : 90	7.06×10^{-5}	2.46
9	-	100 : 0	1.97×10^{-5}	0.87
10	-	0 : 100	2.08×10^{-3}	91.6

TABLE 3 pH of Grout Effluent for Different Mix Ratios

Column No	Trial No.	Mix Ratio Sludge:Fly Ash (dry basis)	pH (High)	pH (Low)	pH (Avg)
1	1	90 : 10	11.1	10.2	10.7
2	1	70 : 30	11.1	10.0	10.6
3	1	50 : 50	10.9	10.1	10.6
4	1	30 : 70	10.8	10.4	10.6
6	1	10 : 90	10.8	10.4	10.7

hydraulic conductivity of the grout mix was similar to that measured for the fly ash alone. Results also indicated that the rate of increase of hydraulic conductivity became more rapid as the fly ash content increased beyond 50 percent. Based on these results, the 50:50 mix ratio was selected as the optimum grout mix. This mix provided the highest fly ash content while maintaining the lowest hydraulic conductivity value.

Grout Effluent Analysis

The outflow from the columns was periodically analyzed. An initial sample was collected from each column after the outflow had begun (zero pore volumes). Sampling was typically performed after every two pore volumes in the initial stages. Outflow for effluent samples was collected in clean, 125-mL polyethylene containers. The containers were rinsed in a 10 percent nitric acid bath. The complete effluent analysis included pH, total alkalinity, total acidity, total iron, manganese, and aluminum.

The pH values of the effluents of all grout mixes ranged from 10.6 to 10.8. Table 3 summarizes the high, low, and average values of pH for each grout tested. The total alkalinity values fluctuated as sampling progressed. Figure 2 shows the general pattern of alkalinity in the effluent with time. The total alkalinity values ranged from a low of 12 to a high of 97 mg/L, which is measured as $CaCO_3$ as shown in Table 4. Typically, the initial alkalinity value was near the middle of the range of values measured for a particular mix. The values then slowly dropped to their lowest level within approximately 10 days. The alkalinity values for each column then began to rise to their highest levels, which were reached at approximately 30 days. The higher levels continued until testing was terminated at 59 days.

Analysis of effluent samples for total iron revealed that a small amount of iron was released during the first sampling period. Afterward, the iron content dropped to less than 1 mg/L for the remainder of the test period for all grout mix ratios. The small amount of iron that was found when the initial samples were collected included a high value of 2.4 mg/L for one column. Remaining columns were between 1.8 and <1 mg/L. Effluent analysis for manganese showed that the concentration was less than 1 mg/L for all grout ratios throughout the testing period.

In the case of aluminum, the trend that was noted for the total alkalinity was generally repeated. The initial aluminum concentration ranged from 1 to 1.8 mg/L. During subsequent testing, the con-

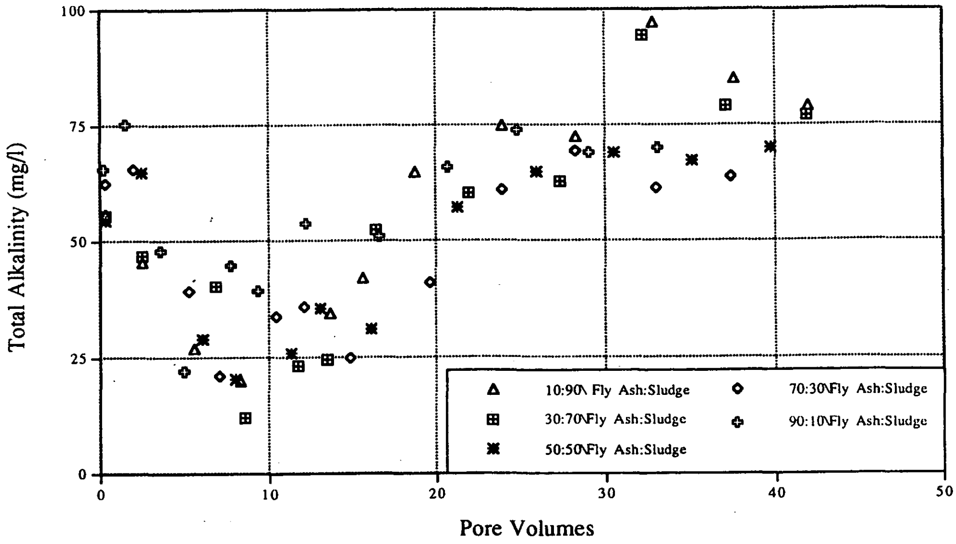

FIGURE 2 Total alkalinity as function of effluent pore volume.

TABLE 4 Total Alkalinity of Grout Effluent

Column No	Trial No.	Mix Ratio Sludge:Fly Ash (dry basis)	Total Alkalinity (High)	Total Alkalinity (Low)	Total Alkalinity (Avg)
1	1	90 : 10	97	20	58
2	1	70 : 30	95	12	52
3	1	50 : 50	70	21	49
4	1	30 : 70	70	21	48
6	1	10 : 90	76	22	57

centrations of aluminum were less than or very close to 1 mg/L but began to rise slowly as testing proceeded. The highest values reached were between 3.6 and 4.0. The increases in aluminum concentrations closely follow the noted increases in alkalinity and pH. Figure 3 shows the change in aluminum concentration with time for the 50:50 sludge fly ash mix ratio. Comparing Figures 2 and 3 shows the coordination of the patterns between the two effluent characteristics.

The reason for the increase in aluminum concentration is not completely clear. However, the following explanation is submitted. Most of the aluminum precipitated from AMD is in the form $Al(OH)_3$ as the pH is driven above approximately 6. This continues to be the predominant form until a pH of approximately 8 is reached. At a pH of 8, an increasing amount of aluminum precipitates in the form of $Al(OH)_4$ which is a soluble form. As the pH rises above 9, $Al(OH)_4$ formation predominates. The pH values for the grouts were all 10 or greater and generally increased with time. Therefore, as time proceeded, additional $Al(OH)_4$ was formed. It is not known for certain whether the aluminum was from precipitated $Al(OH)_3$ that was being converted to soluble $Al(OH)_4$ or it was aluminum leached from the fly ash that became soluble when it was converted to the $Al(OH)_4$ form. In the bench scale grouting trials, the pH of the grouted spoil matrix was low enough that the formation of soluble $Al(OH)_4$ became insignificant.

After the completion of permeation testing, the grout specimens were extracted from the columns. The specimens were cut lengthwise and moisture content samples were taken from the upper, middle, and lower one-third of the length. Physical traits of the specimens were also noted. Each specimen had a gelatinous layer on top. The length of this layer varied but was close to one-third the length of each specimen. The remaining length of each specimen became more soil-like as the bottom of the specimen was approached. The bottom of the specimens were somewhat similar to a clayey silt. The consistency varied between specimens primarily due to the wide range in moisture contents. The range of moisture contents was from 803 to 98 percent.

Figure 4 details the moisture content analysis. The upper portion of the 50:50 mix ratio was lost during specimen extrusion. The results indicate a wide range of moisture contents, both within the specimens and among different specimens. This can be seen more clearly in Figure 4. As a result of the high moisture contents, the grouts were prone to a great deal of shrinkage. No tests were performed to quantify the degree of shrinkage. However, a grout specimen extruded from a 3-in.-diameter column used in a screening pro-

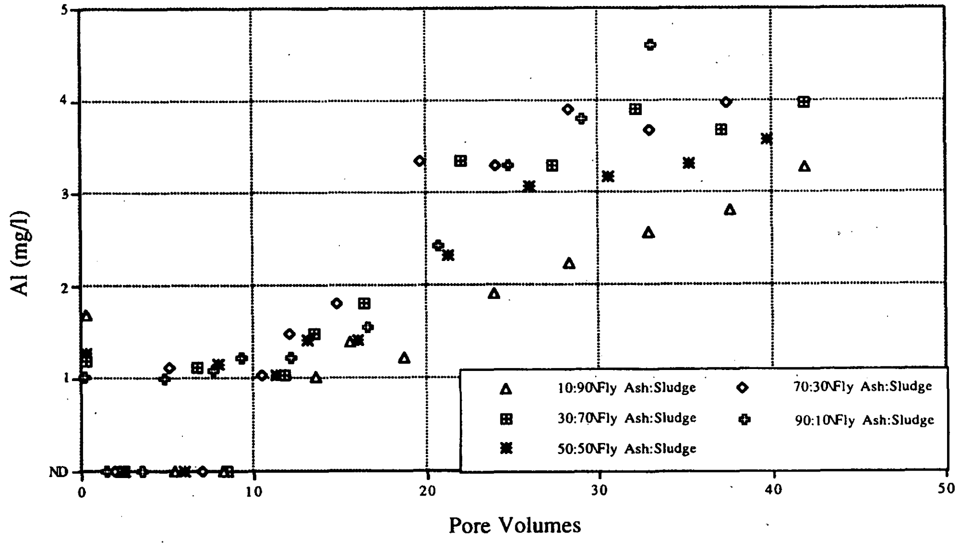

FIGURE 3 Aluminum concentration as function of effluent pore volume.

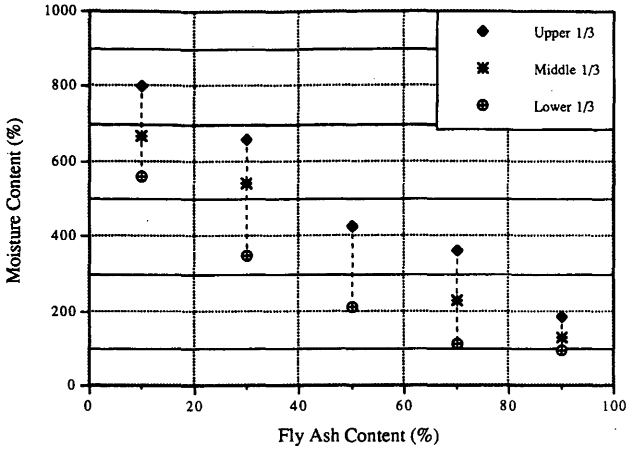

FIGURE 4 Post-permeation grout moisture contents.

cedure was left lying lengthwise and allowed to air dry. Upon drying, the specimen diameter had decreased by at least one-third, and a number of desiccation cracks had formed. Some of the dried specimen was submerged in a beaker of water and left for several weeks. After this period, no noticeable volume change had occurred, and the pieces of grout remained hard. The potential for shrinkage indicates that these grouts may be ineffective in the unsaturated zone.

BENCH SCALE TESTING

Bench scale testing was conducted using three columns 0.27 m in diameter and 1 m long, filled with mine spoil material having grain size distribution as shown in Figure 5. The spoil material mainly consisted of pyritic shale and a small amount of coal. Table 5 summarizes the properties of the three spoil samples.

Each column was fitted with a miniature grouting well that was left in place throughout testing. The wells were constructed using a schedule 40 PVC pipe 432 mm long and 37 mm in diameter. The hydraulic conductivity of the spoil columns was measured using the constant head test method and the specimens were permeated with distilled water. Effluent samples were collected as described during the grout development phase. Grouting was performed using the 50:50 mix ratio of sludge solids and fly ash by percentage of dry weight. The outflow lines of each column were opened, and the specimens were allowed to drain before grouting. Grouting was conducted with a surcharge load of 5.2 kPa and under a maximum grouting pressure of approximately 20 kPa. A summary of the grouting parameters is presented in Table 6.

Hydraulic Conductivity

The measured pregrouting hydraulic conductivity values are presented in Table 7. The dry unit weight and porosity of each specimen are also included. In general, the pregrouting hydraulic conductivity was on the order of 7 × 10^{-2} to 10 × 10^{-2} cm/sec and decreased as the dry unit weight increased. Postgrout evaluation of the hydraulic conductivity was performed for all columns using distilled water as the permeant. The postgrouting hydraulic conductivities were approximately one to two orders of magnitude less than the pregrouting values and ranged from 3 × 10^{-3} to 6 × 10^{-3} cm/sec. This reduction was induced when at least 59 percent of the pore space was grouted.

Effluent Analysis

Effluent samples were collected periodically before and after grouting and analyzed for pH, total alkalinity, total acidity, total iron, manganese, and aluminum. Samples were collected at the onset of permeation, at the first two to three pore volumes of flow, and nearly

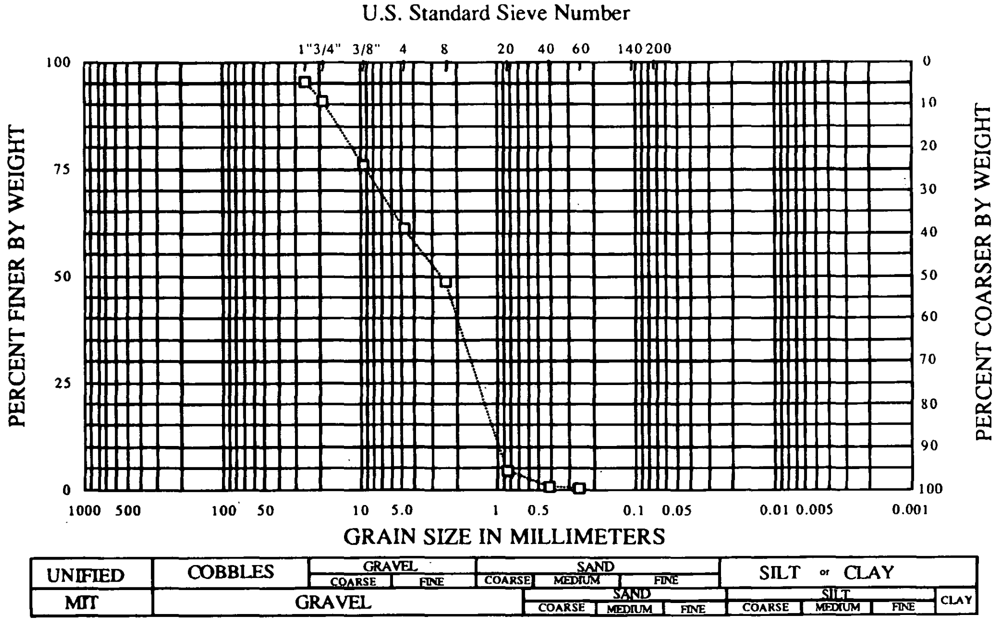

FIGURE 5 Grain size distribution of spoil material used in bench scale testing.

TABLE 5 Properties for Bench-Scale Grouting Specimens

Column Number	Spoil Type	Consol Method	Total Unit Weight (pcf)	Moisture Content (%)	γ_{dry} (pcf)	Specific Gravity (G_s)	Porosity (n)	Void Volume (cm^3)
10	Acidic	3	71.7	1.9	70.4	1.92	0.413	6723
11	Acidic	1	66.5	1.9	65.3	1.92	0.455	7900
15	Acidic	2	68.8	1.9	67.5	1.92	0.426	7104

Consolidation Methods:
(1) No Consolidation: spoil placed loosely
(2) 3 Layers: rod each layer 15 times, apply 5 blows
(3) 5 Layers: rod each layer 25 times, apply 10 blows

TABLE 6 Summary of Grouting Process and Parameters

Column Number	Surcharge Load (psi)	Grouting Pressure (psi)	Volume of Voids (L)	Grout Take (L)	Grouted Void Space (%)
10	0.75	1.5 - 3.0	6.72	5.0	74
11	0.75	1.5 - 3.0	7.90	5.0	63
15	0.75	1.5 - 3.0	8.65	5.0	59

every pore volume thereafter during pregrout testing. Testing was carried out intermittently over a 9-day period. Samples were collected at the end of a selected flow cycle and when flow had been initiated for the first time on a given day. The samples collected at the end of a flow cycle are referenced as "flushed" values. The samples collected at the beginning of a day are referenced as "ponded" values. Results of the effluent analysis for distilled water permeation of the ungrouted spoil are presented in Table 8.

The pregrout effluent concentration values were at their highest during the first few pore volumes of flow. During the next few pore volumes of flow, the values dropped to their lowest levels for both the flushed and ponded samples. All values stayed at the low levels

TABLE 7 Pre- and Postgrout Hydraulic Conductivity Values

Column No.	Dry Unit Weight (pcf)	Porosity (n)	Pre-Grout Hydraulic Conductivity (cm/s)	Grouted Void Space (%)	Post-Grout Hydraulic Conductivity (cm/s)	Ratio k_{post}/k_{pre}
10	70.4	0.413	7.13×10^{-2}	74	3.31×10^{-3}	0.05
11	65.3	0.455	9.85×10^{-2}	63	4.32×10^{-3}	0.04
15	67.5	0.426	7.60×10^{-2}	59	6.24×10^{-3}	0.08

TABLE 8 Pregrout Effluent Values

	pH		Total Acidity (mg/l) (as $CaCO_3$)		Total Iron (mg/l)		Manganese (mg/l)		Aluminum (mg/l)	
Column Number	Pond	Flush	Pond	Flush	Pond	Flush	Pond	Flush	Pond	Flush
10	2.7	3.0	460	125	70.4	8.5	3.3	<1	20.2	2.8
11	2.7	3.1	284	128	39.3	14.7	2.0	<1	9.5	2.6
15	2.7	3.0	300	127	43.5	10.8	2.3	<1	11.1	2.4

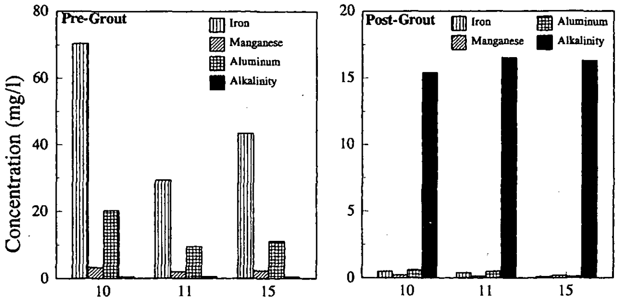

FIGURE 6 Pre- and post-grouting concentration of iron, manganese, aluminum, and alkalinity-distilled water permeation, pH = 8.9 (average values over 40 pore volumes of flow).

for the remainder of the test period. Average values for the characteristics of interest are reported for both flushed and ponded samples in Table 8. Total alkalinity remained below 1 mg/L throughout testing and therefore was not included in the table.

Postgrout effluent sampling was carried out over 40 to 50 pore volumes of flow. The pH of the effluent ranged from 8.6 to 8.9. Alkalinity values were highest at the beginning of the test period. The values remained steady for most of the test period and then dropped to about 7 mg/L for the final few sample periods. A comparison between pre- and postgrouting effluent analysis is shown in Figure 6. Analysis of the iron, manganese, and aluminum revealed effluent levels of less than 1 mg/L for almost every sample during the test period. Occasional small spikes would appear of all three metals, but the concentrations were low and not persistent. These concentrations were generally in the range of 2 to 3 mg/L. At this stage of experimentation, this grout mix appears capable of reducing the hydraulic conductivity by about one order of magnitude.

SUMMARY AND CONCLUSIONS

The development of particulate permeation grouts consisting of fly ash and AMD treatment sludge was investigated. The results of a grout development study indicated that a mix consisting of 50 percent AMD sludge solids and 50 percent fly ash had the best characteristics with regard to flow reduction and pozzolan content. In addition, a grout from this mix was relatively easy to handle and inject. On the basis of the results presented in this study, the following conclusions can be advanced:

- The hydraulic conductivity of the grout increased with increasing fly ash content. The rate of increase was not significant until a fly ash content of approximately 70 percent was reached.
- The total alkalinity values, measured as $CaCO_3$, for all grout tested ranged from 12 to 97 mg/L. The higher levels continued until testing was terminated at 59 days. Total iron and manganese were typically less then 1 mg/L for the remainder of the test period for all grout mix ratios.
- The aluminum concentration ranged from 1 to 1.8 mg/L and began to rise slowly as testing proceeded. The highest values reached were between 3.6 and 4.0. The increases in aluminum concentrations closely followed the noted increases in alkalinity and pH.
- The sludge, and therefore the grout, undergoes significant, nonrecoverable shrinkage on drying. Visual measurements indicated as much as a one-third loss in volume. This area needs further investigation before the developed grout mixes are used in the field.
- Results from bench scale testing indicated that grouting provided one to two orders of magnitude decrease in the hydraulic conductivity. This reduction was achieved by grouting 59 to 64 percent of the voids.
- Effluent samples from the bench scale testing indicated a pH of 8.6 to 8.9, and iron, manganese, and aluminum of less than 1 mg/L for every sample during the test period.

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