High Performance Zero-Bleed CLSM/Grout Mixes for High-Level Waste Tank Closures Stretegic Research and Development - FY98

by

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SUMMARY

The overall objective of this program, SRD-98-08, is to design and test suitable materials, which can be used to close high-level waste tanks at SRS. Fill materials can be designed to perform several functions. They can be designed to chemically stabilize and/or physically encapsulate incidental waste so that the potential for transport of contaminants into the environment is reduced. Also they are needed to physically stabilize the void volume in the tanks to prevent/minimize future subsidence and inadvertent intrusion.

The intent of this work was to develop several new zero-bleed CLSM mixes, which have a range of properties for use in closure of the HLW tanks. These mixes in addition to the zero-bleed CLSM mixes designed for closure of Tanks 17- and 20-F provide design engineers with a suite of options for specifying materials for future tank closures. The new formulations are cost effective and meet the unique placement and stabilization/encapsulation requirements for high-level waste tank closures.

Results of work completed in the first half of FY98 (funded by SRTC-Strategic Research and Development Funds) are documented in WSRC-TR-98-00271, March 30, 1998. These mixes included cellular zero-bleed CLSM for bulk fill, MF2 and a series of four component reducing CLSM mixes, RG1 to RG6. Subsequent mix designs and testing were funded by SFRD and WSRC/HLW/TFA and are documented in this report. The additional mixes include:

- Three-Component Reducing Zero-Bleed CLSM/grout,
- Three-Component Reducing Zero-Bleed CLSM containing A-Area coal ash and D-Area ash,
- A-Area coal ash CLSM for use as common fill at SRS. This mix was incorporated in the WSRC concrete specification.

The three-component reducing CLSM/Grout mix designs are intended to provide alternatives for the reducing grout and the 2000 psi grout used in the Tank 17- and 20-F closures. The five trial mixes prepared and tested (RGM1-RGM5) meet the requirements for both the reducing grout

(incidental waste encapsulation) and 2000 psi capping grout (intruder barrier).

Six four-component reducing CLSM mixes were also designed and tested (RG1-RG6). Results for the reducing CLSM mixes were presented in WSRC-RP-98-00271. The differences in these two series of reducing CLSM mixes are the number of solid components, which require handling and batching (time and expense), and the compressive strength.

Mix RG3 is recommended as the four component All-In-One mix and all of the RGM mixes, RGM 1-5, are acceptable three component All-In-One mixes depending on the strength required. For the purpose of tank closures, the strength of the fill materials should approximate the minimum requirements. This will limit excessive thermal transients, which can cause subsequent cracking and strength regression and will facilitate the placement schedule since minimal/no time is required for heat dissipation.

The three-component Reducing Zero-Bleed CLSM mixes containing A-Area coal ash, 1ZB-APA to 3ZB-APA, were also designed to meet the All-In-One requirements for tank closure. Mix RGAF3 was recommended as a three component mix for filling the bulk of the tanks. The RGAF series of mixes are cellular CLSM and are intended as an alternative to the zero-bleed CLSM mix used in Tanks 17- and 20-F for the bulk fill. Laboratory and field test results for the RGAF series were previously reported in WSRC-TR-98-271 and 272. The reducing CLSM/grout mixes containing A-Area ash have an added feature of utilizing a waste by-product generated by the A-Area steam plant.

In addition, a mix incorporating A-Area coal ash, 8APA, was developed and field tested for use as common fill at SRS. This formulation is not a zero-bleed mix design. This mix was developed for Environmental Restoration application and for common fill construction applications and was intended to demonstrate beneficial use of by-product waste at SRS. The mix is currently in the SRS concrete specification and arrangements were made to purchase this material in quantities of at least 60 cubic yards/day.

Finally, an alternative admixture system consisting of a mixture of a melamine-base high range water reducer, meladine, and a thickner, Kelco-crete, was tested. All of the mixes in this series, ZB-CLSM-Mel/Kc, generated bleed water. It appeared that the meladine interfered with the hydration/thickening effect of the Kelco-crete.

BACKGROUND

Over 150 high-level waste tanks require closure throughout the DOE complex. Approximately 50 of these are located at the SRS. Closure consists of emptying the tanks, encapsulating the incidental contamination, and stabilizing the void space in the tanks to prevent future subsidence and intrusion. New and improved materials are required to accomplish these objectives and enable placement under difficult conditions. Improved materials will provide flexible placement and encapsulation in addition to being cost effective. These materials can also be used to close/stabilize underground pipelines and tanks in the commercial sector (nuclear, chemical, underground mining, and petroleum industries as well as the municipal services business).

As a result of the FY97 effort to design materials for the SRS High-Level Waste Tank closure effort, a zero-bleed Controlled Low Strength Material (CLSM) and a zero-bleed 2000 psi grout were formulated and used to close Tanks 17- and 20-F.[1,2] As a result of the FY98 effort, an alternative cellular zero-bleed CLSM and reducing CLSM for contaminant stabilization/encapsulation were developed and field tested.[3] These mixes provide a wider range of engineering properties for the zero-bleed formulations and are lower cost alternatives compared to the materials used in the first two SRS tank closures.

Two invention disclosures were prepared (zero-bleed admixture system and zero-bleed CLSM) in FY98. Currently, these two disclosures are being combined into one patent application. Two technical papers were presented on this work in FY98.

In addition, the zero-bleed CLSM mix used to close Tanks 17- and 20-F was used to cap a cell in Z-Area Vault 1 during FY98. Other applications at SRS, such as physical stabilization of underground pipelines and small tanks/vessels, are currently under review by the Environmental Restoration and Solid Waste Departments.

Finally, this effort supports stabilization of underground tanks and pipelines in the private sector. Examples of potential applications include closure of abandoned oil and gas pipelines, closure of abandoned water and sewer lines, closure/stabilization of underground petroleum and chemical tanks.

OBJECTIVES

The objective of this report is to document the status of this SRD 98-08 for FY98. The mixes, which were developed in the second half of the year, are described in this report. The experimental program and mixes developed in the first half of FY98 are documented in WSRC-TR-98-00271. The formulations recommended as the result of this effort make up a suite of mixes, which have a range of engineering properties, provide unique features, and are cost effective options for future tank closures.

The objective of the work conducted in the second half of FY98 was to design zero-bleed reducing CLSM/grout mixes, which are low-heat mixes compared to the reducing grout used in Tank 17- and 20-F and which contain only three dry solid ingredients. The previous reducing All-In One CLSM mix designs contained four dry solid ingredients, cement, slag, Class F fly ash, and sand.

Reduction in the number of solid components from 4 to 3 in the All-In-One Reducing grout/CLSM mix design is desirable. The mixes developed in this study contained cement, slag, fly ash, and sand. Eliminating one of these ingredients will simplify calibration, materials storage, and feeding in a continuous auger batch plant. (The number of solid ingredients does not impact the operation and efficiency of a central mixing plant as much as it does a mobile auger plant.)

In addition, a mix incorporating A-Area coal ash was designed and field tested for common fill applications. This mix was incorporated in the current WSRC concrete specification.[4]

Finally, an alternative admixture system consisting of a melamine-based high range water reducer and a thickener was tested. This effort was intended to identify a similar but less expensive zero-bleed system.

LABORATORY TESTING

Trial mixes were then designed and tested at the on-site Raytheon concrete testing laboratory. The tests, test protocols, and acceptance criteria are listed in Table 1. Mix designs were modifications of previous zero-bleed CLSM mixes, which met the criteria for tank closure materials. The zero-bleed admixture system used in these mixes was the Advaflow/Kelco-Crete system identified in the FY97 studies. The fly ash was replaced with slag in the three-component All-In-One grout/CLSM mix designs. In this way, the same proportion of fines to sand was achieved.

Field testing was conducted on only one mix, 8APA, the common fill CLSM containing A-Area coal ash. This testing was limited to batching three cubic yards (transferring, weighing, and mixing) at the Blue Circle ready mix plant in Jackson, SC. This type of central mixing is applicable to the small volume uses encountered in typical construction and environmental restoration work.

The A-Area ash was collected from the stockpile at the Blue Circle ready mix plant in Jackson, SC. Characterization of the A-Area ash is provided elsewhere.[5,6] The moisture content of the A-Area ash was determined for material used in each mix. The amount in each mix includes the water associated with the A-Area ash.

RESULTS AND DISCUSSION

Three-Component Zero-Bleed Reducing Grout/CLSM

Five trial mixes (RGM1-RGM5) with a range of cement contents, were prepared and tested. The mix designs are shown in Table 2. Test results are presented in Table 3. All of the formulations resulted in zero-bleed mixes with flows of more than 11 inches. Consequently, all of these mixes are pumpable and self-leveling based on the experience with Tank 17- and 20-F closures.

The 28-day strengths varied form 1495 to 2935 psi. The 90-day compressive strengths ranged from 1960 to 3550 psi. The zero-bleed feature of these mixes was obtained by using the Advaflow and Kelco-Crete admixture system. All of the mixes contained premixed Advaflow and Kelco-Crete (90 fluid oz. and 275 grams, respectively) per cubic yard of grout. This combination of admixtures was identified in the previous work on zero-bleed CLSM.[1,2]

Three-Component Zero-Bleed Reducing A-Area Coal Ash CLSM/Grout

Three trial reducing CLSM mixes were made with A-Area coal ash (1ZB-APA to 3ZB-APA). Mix designs are shown in Table 4 and results are shown in Table 5. All of the designs resulted in zero-bleed mixes with flows of 10.5 to 10.75 inches. Consequently, all of these mixes are pumpable and self-leveling based on the experience with Tank 17- and 20-F closures.

The 28-day strengths varied form 2150 to 2270 psi. The 90-day compressive strengths ranged from 3125 to 3200 psi. The zero bleed properties of these mixes were obtained by incorporating a mixture of Advaflow and Kelco-Crete in the designs.

CLSM/Grout Containing Alternative Admixtures

Two mixes containing an alternative admixture system, ZB-CLSM-Mel/Kc and ZB-CLSM2-Mel/Kc, were batched and tested for processing and compressive strength. Mix designs are shown in Table 6 and test results are presented in Table 7. The meladine-Kelco-Crete admixture system was not effective in eliminating bleed water/solids settling. The meladine component effectively reduced the water requirement for a self-leveling slurry. However, it appeared to interfere with the thickening action/hydration of the Kelco-crete since these mixtures generated bleed water.

Common Fill CLSM Containing A-Area Coal Ash

Eight trial mixes containing A-Area Coal Ash (1APA to 8APA) were prepared and tested for use as common fill. All of the mixes had bleed water. Zero-bleed is not a requirement for common fill. Mix designs and results are shown in Tables 6 and 7, respectively. Based on flow and strength, Mix 8APA was field tested and subsequently selected for site use based on strength, flow, and uniformity.

CONCLUSIONS

New materials were designed and tested for filling, capping and stabilizing the SRS Type IV High-Level Waste Tanks. The Type IV Tanks are empty 1.3 million-gallon carbon steel vessels without cooling coils, pump shafts, or other equipment and obstructions. Since the results of the laboratory testing and pilot-scale testing of unobstructed tanks were verified in the actual Tank 17- and 20-F closures, there is a good correlation between laboratory results, acceptance criteria and successful placement in Type IV tanks.

To date, all pilot-scale testing of grout placement (Construction Technology Laboratory 45-foot flow tests[3] and WSRC 45-foot flow tests[1] and "swimming pool" tests) was limited to flow in open, unobstructed forms. Additional pilot-scale testing will be required to identify acceptable flow properties and placement strategies for tanks with cooling coils and other obstructions which reduce the ability of the grout to flow. Pilot-scale testing is also recommended for identifying grout flow properties and placement strategies to fill the annulus space in the Type I, II, and III Tanks.

The work conducted in FY98 was directed to identifying alternative fill materials for closure of future HLW Type IV tanks at SRS. Recommended formulations are intended to expand upon the previously developed materials to provide a suite of CSLM and grout mixes with unique engineering and cost effective features.

The following new materials were developed and tested in FY98 and are reported else where:[1,2]

- A four-component reducing CLSM/Grout, Mix RG3, is recommended as an All-In-One mix. This zero-bleed, reducing grout/CLSM is based on modification of the formulation of the CLSM used to fill Tanks 17- and 20-F. This mix contained the Advaflow-Kelco-Crete admixture system.

- A cellular zero bleed CLSM, MF2, was formulated for potential use as a bulk fill in the HLW tanks. An alternative HP-ZB admixture system (MAXFLOW AIR plus MAXFLOW RMA) was identified for this light-weight CLSM. This new admixture system contains a foaming agent that is used to generate a pre-formed foam and a compatible fluidifying (HRWR) reagent. This alternate system is less expensive than the Advaflow-Kelco-crete system used in the Tank 17- and 20-F closures. A cost savings of about $8 per cubic yard was estimated for the cellular HP-ZB CLSM versus the tank 17- and 20-F HP-ZB CLSM.[2]

- Mix RGAF3 was identified as a potential alternative to the bulk fill zero-bleed CLS. This mix contains the pre-formed foam admixture system and the A-Area coal ash. It is a three-component zero-bleed cellular CLSM. This mix is not a reducing formulation. A-Area ash was used in place of all of the sand in the CLSM mix design. About 1500 pounds of A-Area ash can be used per cubic yard of HP-ZB CLSM. This ash is not suited as a complete replacement for all of the fly ash in the CLSM mix. Consequently, fines must be added as Class F fly ash, and/or cement.

- A reducing zero-bleed CLSM mix containing D-Area coal ash (RGD2) was also successfully formulated and evaluated in the laboratory. This mix was the first successfully formulated All-In-One CLSM. The original Advaflow-Kelco-crete admixture system was used.
  The D-Area ash can replace all of the fly ash or all of the sand plus the fly ash in HP-ZB CLSM formulations. About 1700 pounds of D-Area ash can be used per cubic yard of HP-ZB CLSM if both the sand and Class F fly ash are replaced. Slag was used in this mix in the same amount as used in the CTL reducing grout (210 lbs/cyd).

The following new materials were developed and tested in FY98 and are summarized in this report:

- Five different three-component reducing CLSM /grout mix (RGM1 to RGM5) were developed which can be used in place of the reducing grout and 2000 psi grout used in the Tank 17- and 20-F closures. All of these mixes are suitable alternatives for these materials. Selection of a three-component reducing CLSM/grout mix will depend on the 28- and 90-day compressive strength requirements specified for future closures. All of these mixes can be used as All-In-One mixes.

- Three-component zero-bleed, reducing CLSM/grout mixes containing A-Area coal ash were also developed (1ZB-APA to 3ZB-APA). These mixes are also suitable alternatives for the reducing grout, 2000 psi grout, and CLSM used in the Tank 17- and 20-F closures. These mixes are All-In-One designs, which incorporate an SRS by-product as a major component.

- A common CLSM fill containing A-Area coal ash (8APA) was developed and field tested for use in construction and environmental restoration applications at SRS. Based on results obtained in

this study, an A-Area coal ash CLSM mix was added to the WSRC concrete specification (C-SPS-G-00085, Rev. 3) and is available in 100 cubic yard (minimum) quantities from the Blue Circle Ready Mix Plant in Jackson, SC.

A summary of the mixes determined to meet the acceptance requirements closing the SRS Type IV HLW Tanks is shown below. The All-In-One mixes meet the requirements listed in Table 1 for the reducing grout, the bulk fill CLSM and the 2000 psi capping grout. The All-In-One mixes are also referred to as reducing grout/CLSM. The CLSM mixes meet the requirements for the bulk fill since they have compressive strengths less than the minimum requirement for either the reducing grout or the capping grout.

Type IV Tanks	Mix Identification
Bulk Fill Used in Tanks 17-F and 20-F	HP-ZB CLSM
All-In One Mix Reducing CLSM/Grout (4-component)	RG3 field tested RG1 to RG6
All-In-One Mix Reducing CLSM/Grout (3-component)	RGM1, RGM2, RGM3, RGM4, RGM5 Mixes cover a range of compressive strengths)
All-In-One Mix Reducing CLSM/Grout Containing A-Area Coal Ash Containing D-Area Coal Ash	1ZB-APA, 2ZB-APA, 3ZB-APA RGD2
Bulk Fill Cellular CLSM	MF2
Bulk Fill Cellular CLSM Containing D-Area Ash	RGAF3
Common Fill CLSM Containing A-Area Ash for common construction applications	8APA

FUTURE WORK

The following activities are suggested as additional work to support closure of all types of HLW tanks at SRS. Although the mix designs are recommended for only the Type IV tanks at this time, the information is applicable to the overall tank closure program.

- Test reactive additive/aggregate zero-bleed CLSM for chemical stabilization of contaminants. These results will support stabilization of soluble contaminants the tank. Conduct comparative leaching studies with and with out additives.

- Measure chemical and physical properties of reducing CLSM/grout.
  These tests will be used to support the HLW Tank Closure contaminant transport modeling.
  - Measure E_h on RG3 and RGM1-5 series slurries and leachates.
  - Collect shrinkage and permeability data on cellular CLSM. Use mix RGAF3 or MF2.
  - Collect shrinkage and permeability data on RG3 or RGM1-5.

- Identify additional HP-ZB admixture systems.
  This effort may result in a less expensive dispersant which is compatible with Kelco-Crete. This could result in lowering the materials cost for the HP-ZB admixture system and thereby lower the cost of the HP-ZB tank fill mixes.
  - Contact Japanese companies for other polyacrylic carboxylic acids.

- Develop a zero-bleed soil CLSM as an alternative for tank fill material. HP-ZB soil CLSM mixes have potential applications other as than tank fill materials. For example these mixes may be useful in landfill capping, landfill stabilization and environmental restoration (basin stabilization and pipeline closure) applications.

- Develop zero-bleed concrete for tank fill applications. An HP-ZB concrete which has flow properties similar to the HP-ZB grout may have application for filling open tanks with at least 12 inch access ports, which do not contain obstructions.

Pilot-scale testing to simulate Types I, II, and III tanks containing cooling coils, pump shafts, and other obstructions and the annulus space in these tanks is recommended for the SRD program for FY00. Mix RG3 and the CLSM used in the Tank 17- and 20-F closures and a central discharge point are recommended for the initial testing. Based on results, acceptance criteria for the fill materials and/or the fill strategy can be modified if necessary.

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3. WSRC-TR-97-0102, T. B. Caldwell, Tank Closure Reducing Grout (U), April 15, 1997

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QUALITY ASSURANCE

Testing was conducted in accordance with ASTM standard practices and SRS procedures. Results are recorded in Laboratory Notebooks WSRC-NB-97-00506, WSRC-NB-98-00185 and WSRC-NB-98-00186.

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BSRI Construction provided support in operating the pump and preparing the 48 foot long form for the final testing.

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Table 1. Acceptance Criteria for Zero-Bleed CLSM and Common Fill.

PROPERTY	ASTM REFERENCE	HLW TANK FILL ACCEPTANCE CRITERIA
Flow	D- 6103	10 inches (minimum)
Bleed Water.	C-232	Zero vol. % after 24 hr
Air Content	C-231	N/A
Unit Weight	C-138	80 lbs/ft^3 (minimum)
Set Time	C-403	30 hours (max.)
Compressive Strength	C-39	
Reducing grout/CLSM 7 days		50 psi (min.)
28 days		500 psi (min.)
56 days		500 psi (min.)
Cellular CLSM and HP-ZB Coal Ash CLSM		
7 days		20 psi (min.)
28 days		50 psi (min.)
56 days		120 psi (min.)
2000 psi grout 28 days		2000 psi (min.)
Common fill 28 days		30 to 150 psi

Table 2. Mix designs for Three-Component Reducing CLSM/Grout.

INGREDIENTS	RGM1	RGM2	RGM3	RGM4	RGM5
Cement, Type I, lbs/cyd	50	150	75	150	120
Slag, Grade 100, lbs/cyd	510	410	585	510	440
Sand, ASTM C-33, lbs/cyd	2300	2300	2300	2300	2300
Water, gals/cyd	60	60	60	60	60
Advaflow, fl.oz/cyd	90	90	90	90	90
Kelco-crete, gms/cyd	275	275	275	275	275

Table 3. Test Results for Three-Component Reducing CLSM/Grout Mixes.

Mixes	Flow (in.)	Bleed Water (%)	Unit Wt. (lbs/cft)	Air Content (%)	Temp. (°F)	Compressive Strength (psi) 14-day	28-day	90-day
Reducing Grout Acceptance Criteria	10 min.	0	80 min.	N/A	90 max.	50 * min.	500 min.	500 min.
CTL Reducing Grout	4# seconds	0	128	4	85	6570	9725	10,700
HP-ZB CLSM	10.50	0	125	5.2	80	**	230	710
TEST MIXES								
RGM1	11.75	0	115.3	9.5	73	1365	1495	1960
RGM2	12.5	0	123.3	6.2	75	1100	2100	2630
RGM3	11.5	0	123.5	6.5	76	1810	2350	2950
RGM4	11.5	0	123.5	7.2	72	1915	2405	2970
RGM5	11.5	0	122.1	9.2	75	2415	2935	3550

* The original acceptance developed by WSRC and CTL was greater than 500 psi after 72 hours.
** No Cylinders Were Made
# Flow evaluated by the Japanese specification, Kordan 304.[3]

Table 4. Mix Designs for Three-Component Reducing CLSM/Grout Containing A-Area Coal Ash.

INGREDIENTS	1ZB-APA	2ZB-APA	3ZB-APA
Cement, Type I, lbs/cyd	100	150	200
Slag, Grade 100, lbs/cyd	450	400	350
A-Area Coal Ash, lbs/cyd	1350*	1350*	1350*
Water, gals/cyd	73	75	76.5
Advaflow, fl.oz/cyd	180	180	180
Kelco-crete, gms/cyd	325	325	325

* A-Area Coal Ash was in a water saturated surface condition (SSD).

Table 5. Test Results for Three-Component Reducing CLSM/Grout Containing A-Area Coal Ash.

MIXES	Flow (in.)	Bleed Water (%)	Unit. Wt. (lbs/cft)	Air Content (%)	Temp. (^{0}F)	Compressive Strength (psi) 7-day	28-day	90-day
Reducing Grout Acceptance Criteria	10 min.	0	80 min.	N/A	90 max.	50 ## min.	500 min.	500 min.
CTL Reducing Grout	4# seconds	0	128	4	85	6570	9725	10,700
HP-ZB CLSM	10.5	0	125	5.2	80	**	230	710
TEST MIXES								
1ZB-APA	10.5	0	99.4	9.8	71	1310@	2150	3200
2ZB-APA	10.75	0	99.6	10.0	73	1450@	2200	3175
3ZB-APA	10.75	0	99.8	10.2	63	1590@	2270	3125

** No Cylinders Were Made
# Flow evaluated by the Japanese specification, Kordan 304.[3]
The original acceptance developed by WSRC and CTL was >500 psi after 72 hours.
@ 14 day strength

Table 6. Mix Designs for CLSM/Grout Containing Alternative Admixtures.

INGREDIENTS	ZB-CLSM-Mel/Kc	ZB-CLSM2-Mel/Kc
Cement, Type I, lbs/cyd	150	150
Class F Fly Ash, lbs/cyd	500	500
Sand, ASTM C-33, lbs/cyd	2300	2300
Water, gals/cyd	50	55
Meladine, fl.oz/cyd	120	117.5
Kelco-crete, gms/cyd	325	275

Table 7. Test Results for CLSM/Grout Containing Alternative Admixtures.

MIXES	Flow (in.)	Bleed Water (%)	Unit Wt. (lbs/cft)	Air Content (%)	Temp. (°F)	Compressive Strength (psi) 7-day	28-day	90-day
Reducing Grout Acceptance Criteria	10 min.	0	80 min.	N/A	90 max.	50 ## min.	500 min.	500 min.
CTL Reducing Grout	4# seconds	0	128	4	85	6570	9725	10,700
HP-ZB CLSM	10.50	0	125	5.2	80	**	230	710
TEST MIXES								
ZB-CLSM-Mel/Kc	12.25	8	133.7	0.5	65	745*	835	2445
ZB-CLSM2-Mel/Kc	11.0	10	133.9	0.6	66	668*	1010	2275

* 13-day compressive strength values.
** No Cylinders Were Made
# Flow evaluated by the Japanese specification, Kordan 304.[3]
The original acceptance developed by WSRC and CTL was >500 psi after 72 hours.

Table 8. Mix Designs for Common Fill/CLSM Containing A-Area Coal Ash.

INGREDIENTS	1APA	2APA	3APA	4APA	5APA	6APA	7APA	8APA
Cement, Type I, lbs/cyd	200	200	200	165	120	120	125	75
Pond Ash, lbs/cyd	1700	1600	1550	1600	1930	1750	1600	1600
Fly Ash, Class F, lbs/cyd	200	300	350	335	380	380	340	390
Water* gals/cyd	100	87.4	85	85	85.4	133	85	85

* The amount of water includes the water associated with the A-Area Coal Ash.
Shading indicates the mix selected for field testing.

Table 9. Test Results for Common Fill/CLSM Containing A-Area Coal Ash.

MIXES	Flow (in.)	Bleed Water (%)	Unit Wt. (lbs/cft)	Air Content (%)	Temp. (°F)	Compressive Strength (psi) 14-day	28-day	90-days
Common Fill Acceptance Criteria	10 min.	NA	80 min.	N/A	90 max.	30 ## min.	150	150 max.
HP-ZB CLSM	10.50	0	125	5.2	80	**	230	710
TEST MIXES								
1APA	10.5	2	96.5	4.1	70	165	250	**
2APA	10.5	2	96.3	4.4	70	235	320	**
3APA	10.75	3	96.7	4.5	72	190	270	705
4APA	10.75	3	97.4	4.4	63	115	160	415
5APA	11	4	96.9	4.8	79	115	155	460
6APA	11	4	86.8	4.2	78	40	55	155
7APA	11.75	5	99.1	4.9	75	55	75	270
8APA	11.5	5	98.4	5.6	81	30	40	77

** No Cylinders Were Made
Shading indicates the mix selected for field testing.