

**WESTINGHOUSE SAVANNAH RIVER COMPANY
SAVANNAH RIVER TECHNOLOGY CENTER**

CLSM BLEED WATER REDUCTION TEST RESULTS (U)

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Revision: 0
Date: April 21, 1997

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SUMMARY

Previous testing by BSRI/SRTC/Raytheon indicated that the CLSM specified for the Tank 20 closure generates about 6 gallons (23 liters) of bleed water per cubic yard of material (0.76 m³).¹ This amount to about 10% of the total mixing water. HLWE requested that the CLSM mix be optimized to reduce bleed water while maintaining flow. Elimination of bleed water from the CLSM mix specified for High-Level Waste Tank Closure will result in waste minimization, time savings and cost savings.

Over thirty mixes were formulated and evaluated at the on-site Raytheon Test Laboratory. Improved low bleed water CLSM mixes were identified. Results are documented in this report.

APPROACH

The strategy for eliminating bleed water from the CLSM was to use a high range water reducing (HRWR) agent to maintain high flow with less mixing water while at the same time using another admixture to prevent the solids (sand, cement, and fly ash) from settling out of suspension. A naphthalene sulfonate-formaldehyde polymer, Daracem 19, (W. R. Grace) a melamine polymer, Melment 330, (W. R. Grace) and a polycarbonated polymer, Advacast, (W. R. Grace) was the HRWR used in all of the modified mixes. Two approaches were for minimizing settling were evaluated:

- 1) Test air generating admixtures (foaming agents) which form bubbles that help support the solids and fluidize the slurry.
- 2) Test an organic polymeric thickener which is compatible with cement systems.

Two foaming admixtures, Darafill (W. R. Grace) and Rheofill (Master builders) were tested. A polymeric thickener, Kelco-Crete (Kelco/Monsanto) was also evaluated.

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The following measurements were made on the modified mixes:

- 1) Flow ACI 229
- 2) Bleed Water ASTM C 232-92a
- 3) Air Content ASTM C 231-91b
- 4) Fresh Unit Weight ASTM C 138-92

Acceptance criteria for this series of experiments was limited to:

- ≥ 10.5 inches of flow
- 0 bleed water
- $< 20\%$ air content (to minimize pumping problems per W. R. Grace recommendation)

RESULTS AND DISCUSSION

Mix designs and results are summarized in Table 1. The cement contents ranged from 100 to 150 lbs/yd³. Fly ash contents ranged from 300 to and 500 lbs/yd³. Sand contents ranged from 2150 to 2300 lbs/yd³. The types and amounts of admixtures and the amount of water were varied.

Initial results indicated:

- Reducing mixing water reduces both bleed water and flow.
- Reducing mixing water and adding a HRWR reduces bleed water without reducing flow. However this did not eliminate all of the bleed water.
- Beyond a certain amount, further addition of HRWR gives no additional improvement in bleed water reduction. Instead it segregates from the CLSM (rises to the surface) as bleed HRWR.
- No bleed water was obtained from CLSM mixes with a high amount of foaming admixture. However, these mixes did not achieve the flow requirement of > 10.5 inches. These mixes had flows of less than 9 inches.
- Darafill (W. R. Grace) gave better results than Rheofill (Master builders) all other parameters held constant.
- Darafill is a liquid. Rheofill is a powder. The powder is easier to incorporate in the mix than the liquid.
- The unit weight for the mixes containing the foaming agents is 10 to 15 % less than the original reference CLSM mix.
- CLSM mixes with foaming agents display very little segregation and are more cohesive than the reference mix.
- Mixes containing Kelco-Crete visually appear very cohesive and rather "stiff." However, these mixes are very flowable when subjected to the CLSM flow test.
- Kelco-Crete is available in powder form or as a dispersion in a liquid HRWR. The powdered form was used in these tests. The powder was mixed with a portion of the fly ash and added at the end of the mixing cycle to achieve maximum effect.
- The Kelco-Crete mixes have unit weights of greater than 130 lbs/ft³ (comparable to pumpable concrete) and are expected to be pumpable.
- Increasing the water and/or the HRWR in the Kelco-Crete mixes increased the flow.
- Increasing the HRWR and decreasing the mixing water, decreased the bleed water in the Kelco-Crete mixes.
- Increasing the Kelco-Crete, all other parameters held constant, decreased the flow but also decreased the bleed water.
- Set times of the CLSM mixes were affected by the specific admixtures tested.
- Other modifications, such as, substituting Type III cement for Type I cement in the CLSM mix design did not result in any improvement with respect to bleed water reduction.

CONCLUSIONS

Improved low bleed water mixes were developed as the result of this work. The ingredients and proportions for 2 promising mix designs are listed in Table 2 along with the original CLSM mix specified for High Level Waste Tank Closure.

Two different systems for reducing bleed water were identified. The differences in these systems can be attributed to the very different ways that foaming agent and thickening agent work to prevent settling. The foaming agents add air bubbles to the mix which help to fluidize the slurry and to suspend the solids. This results in flowable light weight mixes with good cohesion and mix uniformity. The thickening admixture adds a polymer structure to the mix which also enhances flow and cohesion while maintaining a unit weight similar to that of pumpable concrete. Selection of the system best suited for a backfill will depend on the specific engineering requirements of that application.

Two mixes one from each system are listed in Table 2. Field mixing and pumping tests were conducted to confirm the laboratory results and to finalize a mix design for High-Level Waste Tank Closure. Mixing was conducted in a Ready Mix truck. Mix Q was more difficult to pump than Mix TW-10. Mix Q also showed some sand segregation as a result of pumping.

RECOMMENDATIONS.

Based on the laboratory and field batching and pumping tests, Mix TW-10 is recommended for Tank Closure Specification, C-SPP-F-00038. A DCF must be submitted and approved.

Field mixing and pumping must be evaluated for specific equipment supplied by Throop and BSRI at the F-Area portable batching plant.

REFERENCES

WSRC-RP-96-554, N. Rajendran, C. Langton and T. M. Nixon, Bleed Water Testing Program for Controlled Low Strength Material (CLSM) (U), 10/22/96.

TABLE 1 - Modified CLSM Mix Designs and Test Results for Bleed Water Reduction Program

Mix #	Cement Type I lbs/cyd	Fly ash Class F lbs/cyd	Sand C-33 lbs/cyd	Water gal/cyd	HRWR oz/cyd	Darafill oz/cyd	Rheofill gms/cyd	Kelco-Crete gms/cyd	Flow (Ave.) inch	Bleed Water~ vol. %	Air Content %	Fresh Unit Wt lbs/cuft	Compressive Strength Psi
C	100	300	2230	50.8	-	2.0	-	-	10.4	7.5 (24 hr)	20.5	105.3	45 (28 d)
D	100	400	2300	40.9	-	2.5	-	-	10.4	5.1 (24 hr)	17.0	107.7	
E	100	400	2200	50.0	-	2.5	-	-	10.5	5.7 (24 hr)	20.0	107.2	45 (28 d)
F	100	450	2150	49.23	-	3.0	-	-	10.0	4.2 (24 hr)	19.0	109.9	
G	100	450	2100	51.7	-	3.5	-	-	10.5	6.3 (24 hr)	17.0	102	
H	100*	400	2150	52.5	-	3.5	-	-	11.5	4.5 (24 hr)	14.0	113.2	
I	100	400	2150	48.2	-	3.5	-	-	11.1	3.5 (24 hr)	19.5	106.4	
J	100	400	2250	49.9	-	3.5	-	-	10.5	3.3 (24 hr)	17.0	112.9	
K	100	400	2150	44.0	40 +	3.5	-	-	10.3	>10	20.0	105.6	
L	100	400	2250	42.5	60 +	3.5	-	-	10.8	>10	19.0	109.1	
P	100	400	2200	47.5	45 +	4.0	-	-	10.5	>10	18.5	110.7	
Q	100	400	2150	47 (max.) 38 (min.)	45 +	4.5	-	-	11.0	2.0 (3 hr) 0 (24 hr)	20.5	106.0	40 (14 d)
Q-2	100	400	2150	36.8	45 +	4.5	-	-	9.0	0	23.0	103.0	50 (7 d) 56 (14 d)
R	100	400	2150	52.8	-	-	80	-	11.8	6.4 (24 hr)	23.0	96.0	
S	100	400	2150	45.0	45 +	-	100	-	11.5	5.5 (24 hr)	25.0	102.0	
T	100	300	2300	43.8	45 +	-	100	-	11.5	6.0 (24 hr)	20.0	106.2	
V	100	400	2150	57.0	-	-	-	267.6	11.0	>10	3.0	131.2	
A	100	400	2150	46.4	135.3 +	-	-	340.0	11.5	>10	3.2	130.3	
A-1	150	500	2300	45.6	101.4 +	-	-	227.0	8.4	0.4 (24 hr)	2.8	133.5	
A-2	150	500	2300	51.3	101.4 +	-	-	227.0	12.0	0.6 (24 hr)	1.8	132.8	
A-3	150	500	2300	45.6	101.4 +	-	-	227.0	8.3	0.5 (24 hr)	5.5	129.7	
A-10	150	500	2300	52.2	135.3 +	-	-	341.0	10.5	0 (4 d)	3.5	136.8	
A-4	150	500	2300	51.3	169.1 +	-	-	227.0	10.5	2.8 (4d)	3.2	131.0	

* Type III Cement used
 Highlighted mixes gave promising results
 ~ Percent bleed water is calculated as follows: volume of mixing water divided by volume of the bleed water times 100.
 + Daracem 19

TABLE 1 Continued.

Mix #	Cement Type I lbs/cyd	Fly ash Class F lbs/cyd	Sand C-33 lbs/cyd	Water gal/cyd	HRWR oz/cyd	Daradfill oz/cyd	Rheoifill gms/cyd	Other Admixture lbs/cyd	Kelco-Crete #1049917K gms/cyd	Flow (Ave.) inch	Bleed Water~ vol. %	Air Content %	Fresh Unit Wt lbs/cuft	Compressive Strength, Psi
TW-1	150	500	2300	55.1	73.5 +	-	-	6.5 Ca(OH) ₂	341	10.8	0 (2 hr) 0 (15 hr)	-	-	100 (7 d)
TW-2	150	500	2300	53.9	73.5 +	-	-	4.9 Ca(OH) ₂	300	11	<2% (2 hr) 0 (15 hr)	-	-	90 (7d)
TW-3	150	500	2300	62.9	77.6 ++	-	-	-	341	11	<1% (2 hr) 0 (15 hr)	-	-	95 (7d)
TW-4	150	500	2300	62.9	75 ++	-	-	-	341	10.5	0 (2 hr) 0 (15 hr)	-	-	82 (7d)
TW-5	150	500	2300	62.9	135 **	-	-	-	341	10.6	0 (2 hr) 0 (15 hr)	-	-	118 (7d)
TW-6	150	500	2300	62.9	75 ++	-	-	-	275 ^a	11.25	<2% (2 hr) 0 (15 hr)	-	-	85 (7d)
TW-7	150	500	2300	63	75 ++	-	-	3 (CaNO ₃) ₂	275 ^a	11.25	<1% (2 hr) <1% (15 hr) 0 (36 hr)	-	-	86 (7d)
TW-8	200	450	2300	65.5	75 ++	-	-	-	275 ^a	11	<2% (2 hr) <2% (15 hr) 0 (36 hr)	-	-	118 (7)
TW-9	150	500	2300	65.5	75 ++	-	-	-	275 ^a	11 10.5, 5 min rest 8.4, 17 min rest 9.5, remix	3% (2 hr) 2% (15 hr) 0 (36 hr)	7.8	124	158 (7d)
TW-10	150	500	2300	63	75 ++	-	-	-	275 ^a	12.5	1% (2 hr) 0 (15 hr)	9	123	88 (7d)

* Type III Cement used
 Highlighted mixes gave promising results
 ~ Percent bleed water is calculated as follows: volume of mixing water divided by volume of the bleed water times 100.
 + Daracem 19
 ++ Adva Cast
 ** Melment 33

TABLE 2 - Summary of Improved CLSM Mix Designs and Reference Tank Closure Mix

MIX #	Cement Type I lbs/cyd	Fly ash Class F lbs/cyd	Sand C-33 lbs/cyd	Water gals/cyd	HRWR oz/cyd	Darafill oz/cyd	Kelco-Crete gms/cyd	Remarks
Q	100	400	2150	47 (mas.) 38 (min.)	45*	4.5	-	Excellent flow, Zero bleed after 24 hours
TW-10	150	500	2300	63(max.) 60 (min)	75** 90** (max.)	0	275	Excellent flow, Zero bleed after 15 hours
Ref. Mix OPAE XE-X- P-0-X	150	500	2515	66.0	-	-	-	Excellent flow, 10% bleed water after 24 hours

* Daracem 19 (W. R. Grace)

** Advacast or Advaflow (W. R. Grace)