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Relationship Between Flowability and Tank Closure Grout Quality

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EXECUTIVE SUMMARY

After completion of waste removal and chemical cleaning operations, Tanks 5-F and 6-F await final closure. The project will proceed with completing operational closure by stabilizing the tanks with grout. Savannah River Remediation's (SRR) experience with grouting Tanks 18-F and 19-F showed that slump-flow values were correlated with flow/spread inside these tanks. Less mounding was observed when using grouts with higher slump-flow. Therefore, SRNL was requested to evaluate the relationship between flowability and cured properties to determine whether the slump-flow maximum spread of Mix LP#8-16 could be increased from 28 inches to 30 inches without impacting the grout quality. A request was also made to evaluate increasing the drop height from 5 feet to 10 feet with the objective of enhancing the flow inside the tank by imparting more kinetic energy to the placement.

Based on a review of the grout property data for Mix LP#8-16 collected from Tank 18-F and 19-F quality control samples, the upper limit for slump-flow measured per ASTM C 1611 can be increased from 28 to 30 inches without affecting grout quality. However, testing should be performed prior to increasing the drop height from 5 to 10 feet or observations should be made during initial filling operations to determine whether segregation occurs as a function of drop heights between 5 and 10 feet. Segregation will negatively impact grout quality.

Additionally, increasing the delivery rate of grout into Tanks 5-F and 6-F by using a higher capacity concrete/grout pump will result in better grout spread/flow inside the tanks.

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LIST OF ABBREVIATIONS

DOE	Department of Energy
FTF	F-Tank Farm
PA	Performance Assessment
QC	Quality Control
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation
TTR	Technical Task Request

1.0 Introduction

Formulation LP#8-16 was recently used as the bulk fill grout in Tanks 18-F and 19-F.[1] Requirements for this mix were developed by the Savannah River National Laboratory (SRNL).[2] Laboratory tests and scale-up testing was performed to confirm the suitability of this grout for filling Tanks 18-F and 19-F as part of the tank closure process.[3,4]

Savannah River Remediation's (SRR) experience with grouting Tanks 18-F and 19-F showed that slump-flow values were correlated with flow/spread inside these tanks and that less mounding was achieved when using grouts with higher slump-flow. Therefore, a Technical Task Request (TTR) was generated requesting SRNL to evaluate the relationship between flowability and cured properties to determine whether the slump-flow maximum spread of Mix LP#8-16 could be increased from 28 inches to 30 inches without impacting the grout quality.[5] A request was also made to evaluate increasing the drop height from 5 feet to 10 feet with the objective of enhancing the flow inside the tank by imparting more kinetic energy to the placement.

2.0 Discussion

2.1 Increase in Mix LP#8-16 Slump Flow Specification

Based on a review of the grout property data from the quality control sample test reports for Mix LP#8-16 collected from Tank 18-F and 19-F quality control samples, the upper limit for slump-flow measured per ASTM C 1611 can be increased from 28 to 30 inches. As shown in Figures 2-1 and 2-2, compressive strength is not a function of slump-flow over the range of values tested. Figure 2-1 shows the relationship between the averages of two samples for each batch of grout sampled for quality control. Figure 2-2 shows the relationship between the averages of all compressive strength values as a function of slump flow. This relationship is expected to be maintained as long as the grout does not segregate (i.e., show liquid-solid separation on the spread board used in the ASTM C 1611 test). Table 2-1 contains the data used in the graphs. The data was obtained from quality control sample test reports supplied by SRR from samples taken during the recent Tank 18-F and 19-F back fill operations.

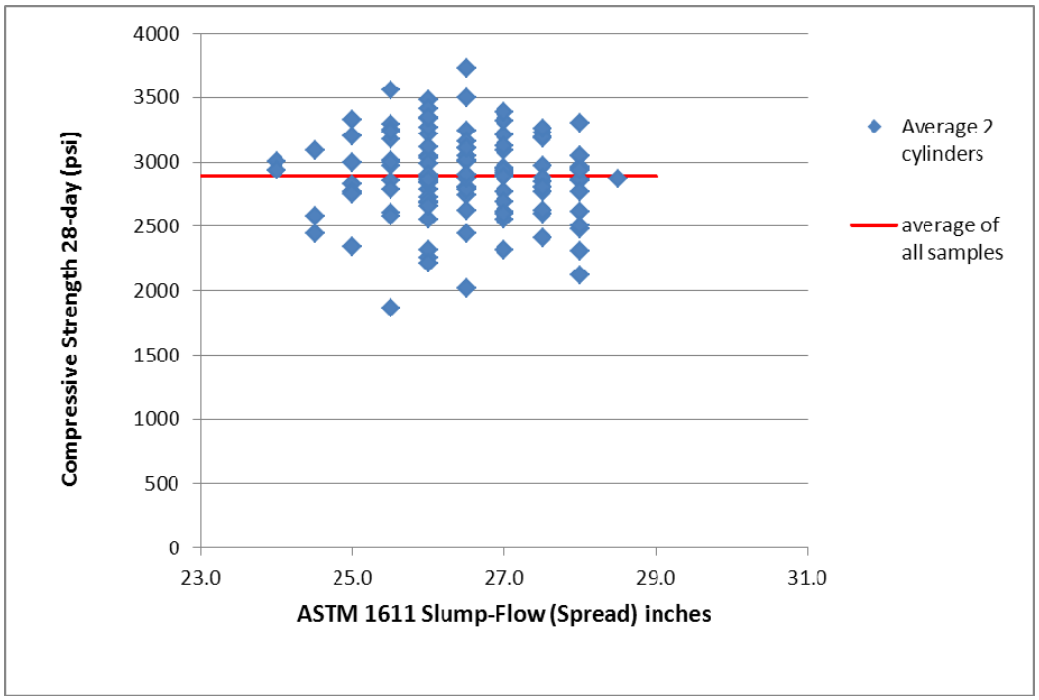

Figure 2-1 Relationship between compressive strength and ASTM C 1611 slump flow for sample LP#8-16 (average of 2 cylinders) collected for quality control during Tank 18-F and 19-F closure.

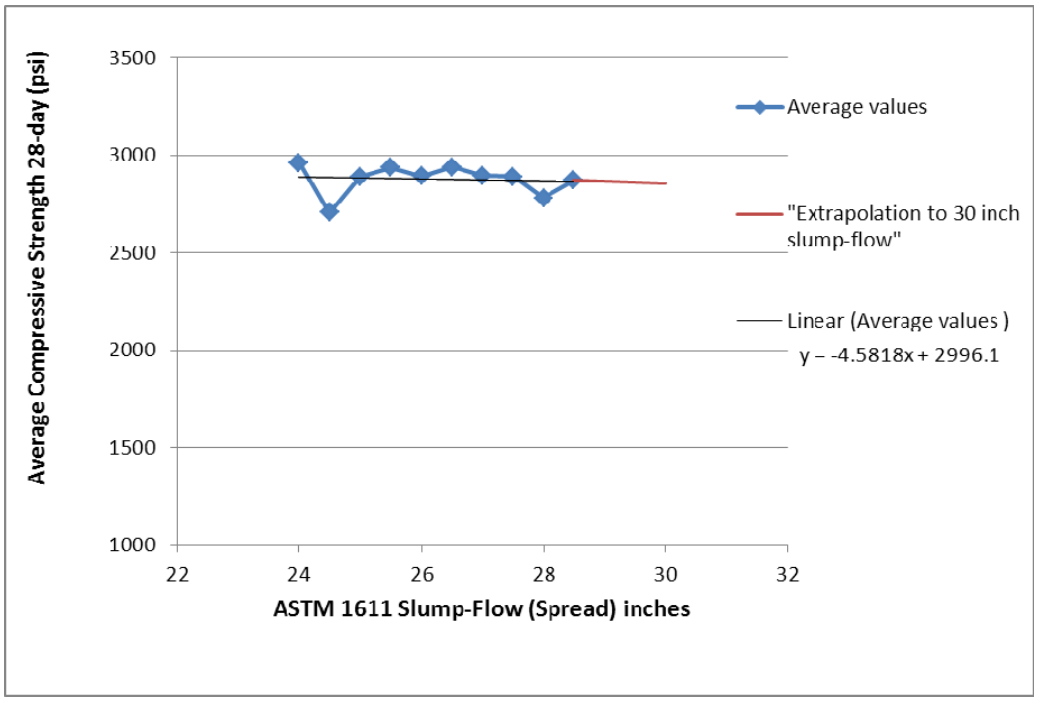

Figure 2-2 Relationship between averaged compressive strength results as a function of ASTM C 1611 slump flow results and projections to a 30 inch flow.

In addition, all of the grout placed in Tanks 18-F and 19-F had the same amount of cementitious material per unit volume and a water to cementitious material ratio of 0.57 ± 0.01 (Note: one gallon of trim water was held back in most cases.). Both of these measures are reliable indicators of grout strength and other cured properties provided that placement and curing conditions are consistent.

2.2 Increase in Mix LP#8-16 Drop Height

Increasing grout flow in Tanks 5-F and 6-F by increasing drop height is also a possibility. The underlying consideration is not to incur segregation during placement. During filling of Tanks 18-F and 19-F, SRR demonstrated that the bulk grout formulation with a slump-flow of 24 to 28 inches did not segregate when the drop height was 10 feet.[6] At this time no data are available to assure that the tank closure bulk fill grout with 28 to 30 inch slump-flows will not segregate when dropped 10 feet. Consequently, testing should be performed prior to increasing the drop height of mixes with up to 30 inches of slump-flow. Alternatively, observations should be made during initial filling operations to determine whether segregation occurs for 10 foot drop heights. As long as no segregation occurs, grout quality should not be affected by a change in drop height. Any segregation will negatively impact grout quality.

2.3 Grout Pumping and Delivery Rate

The risk of uneven grout distribution within the tank is increased for Tanks 5-F and 6-F due to the presence of internal obstructions such as the cooling coils. Consequently actions which will enhance grout flow in the tank, but not impact the quality of the grout, should be considered for implementation. Delivery rate of grout into Tanks 5-F and 6-F should be increased to the extent possible. A higher capacity concrete/grout pump and faster production/delivery rate along with continuous placement at a higher rate will result in better grout spread/flow inside the tanks.

2.4 Grout Quality

Slump-flow, unit weight, and other fresh properties were used for quality control indicators to accept or reject grout deliveries for closing Tanks 18-F and 19-F. Compressive strength was also measured at 28 days to confirm that the bulk fill grout met the cured material requirement of 2000 psi. Compressive strength is not a modeled property in the FTF Performance Assessment (PA). The modeled parameters of interest to the PA include: saturated hydraulic conductivity, effective transmissive porosity, bulk density, particle density, and distribution coefficients for contaminants of concern (K_ds).

Table 2-1. Quality Control Data for Fill Material from Tanks 18-F and 19-F

Batch Ticket No.	Spread/Flow (in)	Average 28 Day Compressive Strength (psi)	Water to Cementitious Material Ratio (lb/lb)
032919	26.5	2800	0.572
032941	27.0	2887	0.567
032947	28.0	2853	0.571
032968	24.0	2937	0.571
032985	26.0	2840	0.567
033007	26.5	2743	0.568
033047	26.0	3220	0.569
033077	25.0	3200	0.562
033101	26.0	3043	0.567
033127	25.0	2827	0.578
033145	25.5	2603	0.568
033169	26.5	2620	0.568
033217	27.5	2763	0.565
033511	24.5	2577	0.579
033636	27.0	2957	0.567
033662	26.0	2787	0.569
033695	26.0	3027	0.565
033726	27.0	2950	0.579
033778	26.0	2720	0.580
033798	26.5	2443	0.568
033867	26.0	2253	0.581
033897	26.0	2317	0.564
034081	24.5	2447	0.577
034097	27.0	2770	0.565
034127	26.0	2883	0.568
034139	26.5	2800	0.569
034158	25.0	2343	0.578
034173	27.0	2617	0.567
034196	25.5	2967	0.563
034911	27.0	2920	0.565
034939	26.0	2680	0.566
034954	25.0	2770	0.567
034985	25.5	2577	0.573

Table 2-1. Quality Control Data for Fill Material from Tanks 18-F and 19-F (continued)

Batch Ticket No.	Spread/Flow (in)	Average 28 Day Compressive Strength (psi)	Water to Cementitious Material Ratio (lb/lb)
034998	26.5	3007	0.561
033359	26.0	2550	0.580
033375	28.0	2617	0.560
033413	27.5	2413	0.563
033430	27.0	2317	0.562
033464	27.0	2693	0.560
033478	26.0	2693	0.565
37720477	26.0	2983	0.566
37720490	26.0	2657	0.569
37720520	25.5	1867	0.570
37720538	25.5	3177	0.580
37720567	27.5	2973	0.566
37720584	26.5	2783	0.567
37720606	27.5	2593	0.564
37720620	27.0	2557	0.561
37720652	25.5	2850	0.576
37720669	28.0	2477	0.563
37720700	24.0	3007	0.581
37720715	28.0	2117	0.565
37720737	25.5	2787	0.569
37720753	27.0	3090	0.561
37720785	25.5	3013	0.575
37720798	27.5	2847	0.564
37720830	27.0	2593	0.561
37720845	26.0	2837	0.577
37720866	25.0	2753	0.561
37720881	26.5	3050	0.582
37720908	26.5	3247	0.559
37720924	27.5	3187	0.560
37720951	25.5	3290	0.561
37720969	28.0	2953	0.563
37721007	27.5	2623	0.558
37721029	26.0	2903	0.561

Table 2-1. Quality Control Data for Fill Material from Tanks 18-F and 19-F (continued)

Batch Ticket No.	Spread/Flow (in)	Average 28 Day Compressive Strength (psi)	Water to Cementitious Material Ratio (lb/lb)
37721060	25.0	3000	0.582
37721077	28.0	2863	0.562
37721086	26.5	3010	0.566
37721101	27.5	3227	0.564
37721139	28.0	2960	0.562
37721158	25.5	3250	0.562
37721172	25.0	3330	0.563
37721187	28.0	3047	0.564
37721223	27.5	2803	0.562
37721259	28.0	2507	0.562
37721265	25.5	3000	0.562
37721289	27.5	3190	0.560
37721373	26.0	2857	0.579
035164	27.5	3263	0.562
035189	26.0	3480	0.562
035212	28.0	2947	0.561
035256	26.5	3160	0.560
035285	28.0	2303	0.565
035321	26.5	3110	0.558
035338	27.0	3207	0.561
035376	27.0	2900	0.580
035393	25.5	3560	0.561
035424	28.0	3043	0.561
035442	28.5	2870	0.562
035463	28.0	2770	0.560
035481	26.5	3497	0.562
035509	27.0	3127	0.562
035522	26.5	3730	0.560
035553	27.0	3320	0.565
035567	28.0	3303	0.563
035590	26.5	3110	0.563
035618	27.0	2933	0.562
035667	27.0	3387	0.561

Table 2-1. Quality Control Data for Fill Material from Tanks 18-F and 19-F (continued)

Batch Ticket No.	Spread/Flow (in)	Average 28 Day Compressive Strength (psi)	Water to Cementitious Material Ratio (lb/lb)
035685	26.0	3337	0.561
037105	25.5	3233	0.560
037121	27.0	2883	0.561
037151	26.5	2867	0.563
037245	26.0	3267	0.579
037259	28.0	2940	0.564
037276	24.0	2940	0.562
037290	26.0	3413	0.564
037340	26.0	3347	0.564
037355	27.5	2873	0.561
037379	26.0	3117	0.561
037396	27.5	2800	0.561
037415	26.0	2217	0.582
037419	24.5	3093	0.577
037478	26.5	2017	0.578
037489	26.5	2900	0.569

3.0 Conclusions

Based on a review of the grout property data for Mix LP#8-16 collected from Tank 18-F and 19-F quality control samples, the upper limit for slump-flow measured per ASTM C 1611 can be increased from 28 to 30 inches without affecting grout quality. However, testing should be performed prior to increasing the drop height from 5 to 10 feet or observations should be made during initial filling operations to determine whether segregation occurs as a function of drop heights between 5 and 10 feet. Segregation will negatively impact grout quality.

Additionally, increasing the delivery rate of grout into Tanks 5-F and 6-F by using a higher capacity concrete/grout pump will result in better grout spread/flow inside the tanks.

4.0 References

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