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Hydraulic
Conductivity,
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Retention: Permanent

HYDRAULIC AND PHYSICAL PROPERTIES OF TANK GROUTS AND BASE MAT SURROGATE CONCRETE FOR FTF CLOSURE

Kenneth Dixon
Mark Phifer

OCTOBER 2007

Savannah River National Laboratory
Washington Savannah River Company
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Aiken, SC 29808

Prepared for the U.S. Department of Energy Under
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SRNL

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CCD	Charge-coupled device
CWST	Contaminated Water Storage Tank
CT	Computed Tomography
EPA	United States Environmental Protection Agency
FFA	Federal Facility Agreement
FTF	F-Tank Farm
GSA	General Separations Area
GTX	Geotesting Express, Inc
INL	Idaho National Laboratory
IQI	Image quality indicator
keV	kilo-electron-volt
K_s	Saturated Hydraulic Conductivity
MCT	Mactec Engineering and Consulting, Inc.
PA	Performance Assessment
SCDHEC	South Carolina Department of Health and Environmental Control
SRIP	Site Regulatory Integration and Planning
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SSC-UFA	Steady state centrifugation–unsaturated flow apparatus
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
WCMR	Water to cementitious materials ratio
WMAP	Waste Management Area Projects
WSRC	Washington Savannah River Company

1.0 EXECUTIVE SUMMARY

The F-Area Tank Farm (FTF) is located within F-Area in the General Separations Area (GSA) of the Savannah River Site (SRS). The GSA contains the F and H-Area Separations Facilities, the S-Area Defense Waste Processing Facility, the Z-Area Saltstone Facility, and the E-Area Low-Level Waste Disposal Facilities. The FTF includes twenty-two waste tanks, which were emplaced between 1951 and 1976. Site Regulatory Integration and Planning (SRIP) is in the process of preparing the regulatory documentation for closure of several of these liquid waste tanks. The current closure concept for all of the FTF waste tanks is to fill the majority of the tank interior with reducing fill grout and fill the very top of certain tanks with a strong grout to protect against inadvertent intrusion after closure.

The Savannah River National Laboratory (SRNL) has been tasked to design and test various tank grouts and a base mat surrogate concrete to support the Performance Assessment (PA) for the FTF (WSRC, 2006). These materials include the following:

- Strong grout B2000-X-0-0-BS (WSRC, 2003)
- Reducing fill grout OPDEXE-X-P-0-BS (WSRC, 2003)
- Alternative reducing fill grout 1A (Ganguly and Langton, 2007)
- Alternative reducing fill grout 1B (Ganguly and Langton, 2007)
- Alternative reducing fill grout 2 (Ganguly and Langton, 2007)
- Base mat surrogate (provided by SRIP)

The specific scope of this task was to measure the physical and hydraulic properties of these materials. The grout formula development for the alternative mixes and wet physical property measurements of each fill material and grout are described by Ganguly and Langton (2007). The purpose of this report is to provide the results of the hydraulic property measurements of these materials.

Three inch diameter mold samples of each material (except the base mat surrogate) were prepared at the site concrete testing facility located in N-Area and allowed to cure for a minimum of 28 days in a controlled environment (Ganguly and Langton, 2007). Three inch diameter core samples were collected from the working slab and base mat of the Contaminated Water Storage Tanks (CWST) located near the P-Area retention basin (904-86G). These samples, which were provided by SRIP, served as a surrogate for the tank base mat concrete. These core samples, along with the mold samples, were submitted to offsite laboratories for testing of hydraulic and physical properties. These services were provided by MACTEC Engineering and Consulting, Inc (MCT) and Geotesting Express, Inc. (GTX) per ASTM standard methods. Properties measured included saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity.

In addition to the testing conducted by MCT and GTX, one inch diameter samples of the reducing fill grout were submitted to the Idaho National Laboratory (INL) to be tested for saturated hydraulic conductivity, unsaturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity. INL used steady state centrifugation-unsaturated flow apparatus (SSC-UFA) to measure the hydraulic properties of the reducing fill grout.

Recommended hydraulic property values for each tank grout and the base mat surrogate are provided. The hydraulic properties provided for each material include the saturated hydraulic conductivity, dry bulk density, particle density, and water exchangeable porosity. In addition, water retention data are presented for each material along with the van Genuchten transport parameters as determined using the RETC code. Finally, selected samples of each material were scanned using computed tomography. Images from these scans are presented to provide a qualitative perspective of the porosity and heterogeneity of each sample.

2.0 INTRODUCTION

The F-Area Tank Farm (FTF) is located within F-Area in the General Separations Area (GSA) of the Savannah River Site (SRS). The GSA contains the F and H-Area Separations Facilities, the S-Area Defense Waste Processing Facility, the Z-Area Saltstone Facility, and the E-Area Low-Level Waste Disposal Facilities. The FTF is a nearly rectangular shaped area and comprises approximately 20 acres, which is bounded by SRS coordinates N 76,604.5 to N 77,560.0 and E 52,435.0 to E 53,369.0. The FTF includes twenty-two waste tanks, which were emplaced between 1951 and 1976 (Figure 1). Site Regulatory Integration and Planning (SRIP) is in the process of preparing the regulatory documentation for closure of several of these liquid waste tanks.

The Federal Facility Agreement (FFA) closure dates for Tanks 18 and 19 are currently under negotiation with South Carolina Department of Health and Environmental Control (SCDHEC) and the United States Environmental Protection Agency (EPA) due to the ongoing evaluation of a new technology for additional waste removal from the tanks. Waste removal operations are currently in progress in Tank 6 and further heel removal is scheduled for both Tanks 5 and 6 to support the current FFA commitment dates.

The current closure concept for all of the FTF waste tanks is to fill the majority of the tank interior with reducing fill grout and fill the very top of certain tanks with a strong grout to protect against inadvertent intrusion after closure.

The Savannah River National Laboratory (SRNL) has been tasked to design and test various tank grouts and a base mat surrogate concrete to support the Performance Assessment (PA) for the FTF (WSRC, 2006). These materials include the following:

- Strong grout B2000-X-0-0-BS (WSRC, 2003)
- Reducing fill grout OPDEXE-X-P-0-BS (WSRC, 2003)
- Alternative reducing fill grout 1A (Ganguly and Langton, 2007)
- Alternative reducing fill grout 1B (Ganguly and Langton, 2007)
- Alternative reducing fill grout 2 (Ganguly and Langton, 2007)
- Base mat surrogate (provided by SRIP)

The specific scope of this task is to determine the physical and hydraulic properties of these materials. The grout formula development for the alternative mixes and wet physical property measurements of each fill material and grout are described by Ganguly and Langton (2007). The purpose of this report is to provide the results of the hydraulic property measurements of these materials. These data will be used to establish material properties for these cementitious materials for use in the PA and closure document development process.

The specific objectives of this task are to:

- Determine the hydraulic properties of the strong grout, reducing fill grout, a base mat surrogate, and three alternative reducing fill grouts including hydraulic conductivity and water retention characteristics.

- Determine the physical properties of the strong grout, reducing fill grout, a base mat surrogate, and three alternative reducing fill grout materials including dry bulk density and porosity.

The sections that follow discuss the methods used to test samples of the tank grouts and base mat surrogate and the results of the testing.

3.0 METHODS

The objective of this testing was to determine the hydraulic conductivity, water retention characteristics, dry bulk density, and water exchangeable porosity of samples of the tank grouts and a base mat surrogate concrete. The following samples were tested to determine hydraulic and physical properties using standard ASTM methods.

- 6 samples of the strong grout (B2000-X-0-0-BS)
- 6 samples of the reducing fill grout (OPDEXE-X-P-0-BS)
- 4 samples of base mat surrogate concrete
- 2 samples of alternative reducing fill grout 1A
- 4 samples of alternative reducing fill grout 1B
- 4 samples of alternative reducing fill grout 2

Two samples of the reducing fill grout were tested using a steady state centrifugation unsaturated flow apparatus (SSC-UFA) at the Idaho National Laboratory (INL). In addition to the hydraulic and physical testing, selected samples of each grout were scanned using computed tomography (CT) to examine the internal structure of the samples and to make qualitative observations regarding connected porosity and preferential flow paths or channels.

3.1 TANK GROUT MOLD SAMPLE PREPARATION

Three inch diameter by six inch in length mold samples of the strong grout, reducing fill grout, and three alternative reducing fill grouts were provided by Ganguly and Langton (2007). Details on the preparation and wet physical property testing of each mix are provided by Ganguly and Langton (2007). These samples were labeled according to the mix and batch of origin as given in Table 1. The samples were capped and stored in a controlled environment for curing. Each sample was cured for a minimum of 28 days prior to hydraulic testing. Samples of each material were tested for compressive strength at the site concrete testing facility located in N-Area (Ganguly and Langton, 2007). Each mold sample was assigned a unique identification number for laboratory tracking purposes (Table 1).

One inch diameter by 12 inch in length mold samples of the reducing fill grout were also prepared using polybutyrate liners. These samples were prepared for testing in the SSC-UFA at INL. The samples were labeled according to the mix and batch of origin as given in Table 1. The samples were capped and stored in a controlled environment for curing. Each sample was cured for a minimum of 28 days prior to hydraulic testing.

3.2 BASE MAT SURROGATE CORE COLLECTION

Four core samples of the base mat surrogate concrete were provided by SRIP. These samples were collected from base mat concrete at the Contaminated Water Storage Tanks (CWST) located near the P-Area retention basin (904-86G). The tanks are 88 feet diameter and 12 feet high carbon steel plate tanks with capacity for 500,000 gallons of liquid. Each tank sits on a eighteen inch thick integrated concrete working slab and base mat. Three CWSTs were built under project 1S-1745 in the late 70's for P, C and K-area.

The core samples were collected using a three inch diameter wet abrasive coring bit and drill motor from the CSWT base mat concrete. The concrete core samples were intended to be representative of Class 3 concrete (DuPont Specification 5B 6 A for 3000 psig concrete) poured at SRS during the 1950s or 1960s, which is assumed to be a suitable surrogate of the tank base mat concrete. A single core of this material was tested for compressive strength at the site concrete testing facility located in N-Area. Each base mat surrogate concrete core sample was assigned a unique identification number for laboratory tracking purposes (Table 1).

3.3 HYDRAULIC AND GEOTECHNICAL TESTING

A total of 26 cementitious samples were submitted for testing per standard ASTM methods to offsite subcontract laboratories. The samples were split among two laboratories in order to meet the project schedule. Samples of the strong grout, reducing fill grout, and alternative reducing fill grout 2 were submitted to Mactec Engineering, Inc. (MCT). Samples of the base mat surrogate concrete and alternative reducing fill grouts 1A and 1B were tested by Geotesting Express, Inc. (GTX). Two samples of the reducing fill grout were tested by INL.

The tank grouts and base mat surrogate were tested using standard methods as indicated in Table 7. Three inch diameter by six inch in height mold samples of the tank grouts were submitted to the designated laboratory. Three inch diameter core samples of the base mat surrogate concrete were submitted to MCT for testing.

Standard ASTM methods were used to test each sample. The ASTM standards of each test are indicated in Table 7 and are summarized below. Except as noted, both labs followed the same procedures.

- Saturated hydraulic conductivity using method ASTM D 5084 - flexible wall permeameter:
    a. MCT - Method B (falling head, constant tailwater pressure)
    b. GTX - Method C (falling head, rising tailwater pressure)
- Water retention characteristics were determined using methods ASTM D 2325 and ASTM D 3152 by pressure plate apparatus.
- Dry bulk density was determined by dividing the dry weight of the sample by the measured volume (modified ASTM C 642).
- Water exchangeable porosity (n) was measured using a modified method of ASTM C 642 as follows:
    a. Sample volume (Vol) was determined by measuring the cylindrical concrete specimens. A minimum of 3 height measurements at 120^{o} from each other and top and bottom

diameter measurements were made to determine the volume. Additional measurements were made as necessary to compensate for any substantial irregularities in the sample.

b. Saturated mass (M_{sat}) of the vacuum saturated, surface dried specimen was measured per the requirements of ASTM C 642 Section 5.2 (i.e. criteria for acceptable mass measurement).
c. Oven-dried mass (M_{dry}) of the specimen was measured per ASTM C 642 Section 5.1 (i.e. criteria for acceptable mass measurement). For many of the samples, it took several days to a week to obtain an acceptable oven-dried mass measurement.
d. Porosity was calculated as:

$$n = ((M_{sat} - M_{dry})/\rho_w) / Vol$$

where p_w = density of water at the temperature used to determine M_{sat}.

- Specific gravity was determined using method ASTM D 854 which is a water pycnometer method.

INL tested two samples of the reducing fill grout using a steady state centrifugation unsaturated flow apparatus (SSC-UFA) following method ASTM D 6527 and procedures given in Methods of Soil Analysis (Dane and Topp, 2002). A complete discussion of the methods used is given in the project report in Appendix B (Mattson, 2007). A total of two, one inch diameter cylinders of the reducing fill grout were provided to INL for testing: TNK019R and TNK020R.

The SSC-UFA was used to estimate the saturated and unsaturated hydraulic conductivity of the reducing fill grout samples. Additionally, the saturated hydraulic conductivity of the samples was estimated using a falling head method as given by Dane and Topp (2002). INL also measured the water retention characteristics of the reducing fill grout samples by testing sub-cores of the grout over a range of pressures from 0 to approximately 45,000 cm of H_2O (~45 bars). A combination of methods was used to establish the water retention curve including hanging column analysis (for the wet end of the curve), pressure plate apparatus (for the middle portion of the curve), and chilled mirror analysis (for the dry end of the curve). See Appendix B for a complete discussion of the methods.

The dry bulk density of the reducing fill grout was determined following the method of Dane and Topp (2002) where the dry weight of the sample is divided by the measured volume (equivalent to ASTM C 642). INL determined water exchangeable porosity in the same manner as MCT and GTX (modified ASTM C 642) where porosity is determined by dividing the volume of the pores by the total sample volume. The volume of the pores is determined by subtracting the dry weight of the sample from the saturated weight of the sample (assuming a density of 1 g/cm^3). The volume of the sample is determined by measuring the physical dimensions of the sample.

3.4 DETERMINATION OF VAN GENUCHTEN TRANSPORT PARAMETERS

Direct measurement of the unsaturated hydraulic conductivity of large numbers of samples of cementitious materials is time consuming and cost prohibitive. An alternative to direct measurement is the use of theoretical methods to predict the unsaturated hydraulic conductivity based upon measured water retention data. These methods are generally based on pore-size distribution models, and have been shown to perform reasonably well for coarse textured soils and other porous media having relatively narrow pore-size distributions (USDA, 1998). The applicability of these models to cementitious materials has not been fully assessed; nevertheless, predictive models based on water retention data provide the most viable means of characterizing the hydraulic properties of large numbers of samples of cementitious materials. Therefore, this method was chosen to predict the unsaturated hydraulic conductivity of the FTF tank grouts and base mat surrogate concrete samples based upon the measured water retention properties of each material.

RETC (RETention Curve) (USDA, 1998), a U.S. Salinity Laboratory computer program designed for analyzing the hydraulic properties of unsaturated soils, was used to fit the measured water retention data for each tank grout and the base mat surrogate. The program's curve fitting is based on van Genuchten's equation for soil water content as a function of pressure

$$\theta(h) = \theta_r + \frac{\theta_s - \theta_r}{\left[1 + (\alpha h)^n\right]^m} \qquad h \le 0$$

$$\theta(h) = \theta_s \qquad h > 0$$

where $\theta(h)$ is water content at the pressure head h, θ_r is residual water content, θ_s is the saturated water content, h is pressure head, α is a constant related to the inverse of the air-entry pressure, and n is a measure of the pore-size distribution. The constraint $m = 1 - 1/n$ was used as suggested by van Genuchten (van Genuchten, 1980; van Genuchten et al, 1991).

All of the generated moisture retention curves were based on water retention data only; no unsaturated hydraulic conductivity data were available for the samples. RETC's (USDA, 1998) van Genuchten $m = 1 - 1/n$ retention curve model was used to estimate curve fitting parameters ($\theta_r, \theta_s, \alpha, n$) for each sample.

The curve fitting parameters ($\theta_r, \theta_s, \alpha, n$) from RETC (USDA, 1998) were used to calculate the effective saturation (or reduced water content), S_e, at incremental pressure heads according to

$$S_e = \frac{S - S_r}{1 - S_r} = \frac{1}{\left[1 + (\alpha h)^n\right]^m}$$

where S_r denotes residual saturation. Using S_e, the relative hydraulic conductivity was calculated at incremental pressure heads using the Mualem-van Genuchten type function

$K = S_e^L\left[1 - \left(1 - S_e^{1/m}\right)^m\right]^2$, where L is an empirical pore-connectivity parameter and assumed to be 0.5.

Saturation (S) was calculated at various pressure heads according to

$$S = S_r + \left(\frac{1 - S_r}{\left[1 + (\alpha h)^n\right]^m} \right)$$

where residual saturation, S_r, is equal to θ_r / θ_s (the residual water content divided by the saturated water content).

3.5 TOMOGRAPHIC EVALUATION OF TANK GROUTS AND BASE MAT SURROGATE CONCRETE SAMPLES

Computed tomographic (CT) imaging was performed on selected samples of the tank grouts, and base mat surrogate samples. A 420 keV x-ray tube was used to acquire the raw projection images for the three inch diameter samples. The detector used was a 1.5K x 1K pixel Photometrics charge-coupled device (CCD) camera with an 85 mm lens viewing an image quality indicator (IQI) glass scintillator. The scintillator converts x-ray energy into visible light which can be imaged with light sensitive detectors.

The samples were placed on a rotational turntable controlled by data acquisition software. The samples were imaged at 0.5 degree increments in the rotational angle for a total of 760 projection images. The raw projection data was processed by subtracting the dark current signal then taking the log of the ratio of the sample image to the un-attenuated beam. This transforms the data into the x-ray attenuation space. The projections were then Fourier transformed and filtered in the frequency domain to produce filtered projections. The filtered projections were then back projected through the object space using a cone beam reconstruction algorithm to provide reconstructed planes perpendicular to the axis of rotation and the raw projection coordinates. The set of reconstructed planes constitutes a 3-D data set which represents the attenuation coefficients of the sample. This 3-D data set was then sliced and viewed from different angles. For ease of viewing, movie files were created showing a sequence of images that are planes perpendicular to the axis of rotation or planes that are parallel to the axis of rotation. From these movies, still images were captured to show the internal characteristics of the tank grouts and base mat surrogate samples.

4.0 RESULTS

A total of 22 tank grout samples were tested to estimate hydraulic conductivity, water retention characteristics, porosity, and bulk density. These samples were all tested following a minimum 28 day cure time. In addition, 4 base mat surrogate core samples were also tested to estimate hydraulic conductivity, water retention characteristics, porosity, and bulk density. Samples were analyzed using traditional geotechnical testing methods as well as using steady state centrifugation. In addition to the hydraulic and physical testing, selected samples of each tank grout and base mat surrogate were scanned using computed tomography (CT) to examine the internal structure of the samples and to make qualitative observations regarding connected porosity and preferential flow paths or channels within each sample.

4.1 COMPRESSIVE STRENGTH TESTING

Mold samples of the tank grouts were tested for compressive strength at 7, 14, 28, 56, 90 and 180 days at the site concrete testing facility located in N-Area. Details on the testing and discussion of the results are provided by Ganguly and Langton (2007) and preliminary results are presented in Table 8 through Table 12 (the detailed compressive strength test reports are provided in Appendix C). Compressive strength testing is of interest for this task because an increase in strength is generally associated with a decrease in hydraulic conductivity. Thus, a substantial increase in compressive strength may be used as an indicator that additional hydraulic testing should be conducted to determine if the hydraulic conductivity of the material has changed.

Both the strong grout and reducing fill grout were made in two batches to have enough material for the required testing. The strong grout batches were labeled 070025.1 and 070025.2. The reducing fill grout batches were labeled 070027.1 and 070027.2. The compressive strength of each batch of strong and reducing fill grout was measured. Per SRS Specification C-SPP-F-00047, Revision 2, the minimum 28 day compressive strength for the strong grout (B2000-X-0-0-BS) is 2000 psig. For the strong grout, it appears there was an issue with batch 070025.2 since it had a 28 day compressive strength of 1060 psig (Table 8). This is substantially less than the design strength (2000 psig). Additionally, it is noted that batch 070025.1 did not meet the design strength at the 28 day test (1520 psig) but did at 62 days.

Per SRS Specification C-SPP-F-00047, Revision 2, the minimum 28 day compressive strength for the reducing fill grout (OPDEXE-X-P-0-BS) is 900 to 1100 psig with a 90 day strength of 1800 to 2100 psig. The results of the strength testing from this mix show that both batches (070027.1 and 070027.2) meet the specification requirements (Table 9).

The compressive strength of each alternative reducing fill grout increased over the curing period with significant gains in compressive strength between 28 and 90 days (Table 10 through Table 12). This is due to the fly ash and slag content of these mixes, which hydrate more slowly than does cement. Therefore, it is likely that the saturated hydraulic conductivity of these grouts decreased between the 28 day and 90 day curing period. It is also noted that each of the alternative reducing fill grouts were significantly stronger than the site specification reducing fill grout (OPDEXE-X-P-0-BS) because these mixes contained significantly more cementitious materials (cement, fly ash, and/or slag).

A single core of the base mat surrogate was also tested for compressive strength. The compressive strength was found to be 2700 psig, which is slightly less than the specification for Class 3 concrete (DuPont Specification 5B 6 A for 3000 psig concrete).

4.2 HYDRAULIC AND PHYSICAL PROPERTIES OF TANK GROUTS AND BASE MAT SURROGATE SAMPLES

MACTEC Engineering and Consulting, Inc (MCT) and Geotesting Express, Inc. (GTX) determined the hydraulic and physical properties of the tank grouts and base mat surrogate using ASTM standard methods, while the Idaho National Laboratory (INL) used the steady state centrifugation unsaturated flow apparatus (SSC-UFA) and standard soil science methods

(Methods of Soil Analysis (Dane and Topp, 2002)). The supporting detailed test reports produced by MCT and GTX are provided in Appendix A, and the report detailing the INL results is included in Appendix B.

4.2.1 Strong Grout Hydraulic and Physical Properties

Six samples from two different batches of the strong grout mix were tested by Mactec Engineering and Consulting, Inc. (MCT) to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 13 and summarized in Table 20. Sample details are given in Table 1. The samples were cured for 28 days prior to shipping them to MCT for testing. The mix design for the strong grout is presented in Table 2. Simultaneous to the testing at MCT, samples from each batch of the strong grout were tested for compressive strength as described in Section 4.1. The results of the strength testing (Table 8) showed there to be an issue with one batch of the strong grout (batch 070025.2); however, the results of the hydraulic and physical property testing were consistent with each other and there was no apparent reason to exclude data from the batch. The saturated hydraulic conductivity of the strong grout ranged from 6.8×10^{-9} to 2.9×10^{-8} cm/sec with an arithmetic average of 2.1×10^{-8} cm/sec. The dry bulk density of the strong grout ranged from 1.78 to 1.81 g/cm^3 with an arithmetic average of 1.80 g/cm^3.

The water exchangeable porosity ranged from 0.257 to 0.277 with an arithmetic average of 0.269. The average porosity of the strong grout is greater than that of a low quality concrete (0.226, Phifer et al., 2006). The increased porosity is most likely related to the high water to cementitious materials ratio (WCMR) for this mix (WCMR = 0.99). The most important factor controlling the porosity of a cementitious material is the WCMR and porosity increases with increasing WCMR above a WCMR of approximately 0.35 to 0.40 (Phifer et al., 2006).

As with hydraulic conductivity, water retention properties of the strong grout samples were determined by MCT and the results are presented in Table 21. The MCT testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 21. A wafer approximately 3 inches in diameter and ½ inch thick from each sample was tested using a pressure plate apparatus. Water retention curves were prepared for each sample and are shown in Figure 2.

4.2.2 Reducing Fill Grout Hydraulic and Physical Properties

Six samples of the reducing fill grout mix were also tested by MCT to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 14 and summarized in Table 20. Sample details are given in Table 1. The samples were cured for 28 days prior to shipping them to MCT for testing. Although two batches of the reducing fill grout were prepared (070027.1 and 070027.2), all six samples tested originated from the same batch (070027.2). The mix design for the reducing fill grout is presented in Table 3. The saturated hydraulic conductivity of the reducing fill grout ranged from 1.0×10^{-8} to 8.5×10^{-8} cm/sec with an arithmetic average of 3.6×10^{-8} cm/sec. The dry bulk density of the reducing fill grout ranged from 1.80 to 1.86 g/cm^3 with an arithmetic average of 1.81 g/cm^3. The water exchangeable porosity ranged from 0.219 to 0.278 with an arithmetic average of 0.266. Similar to the strong grout, the reducing fill grout had an average porosity greater than a low quality concrete (0.226).

The increased porosity is most likely related to the fairly high WCMR for this mix (WCMR = 0.76). Because the reducing fill grout mix contains fly ash and blast furnace slag, the saturated hydraulic conductivity and porosity of this mix may decrease with increased curing time.

Sub-samples from two one inch diameter samples of the reducing fill grout were also tested by the INL (Mattson, 2007). The results from the INL testing are presented in Table 15. These samples came from batch 070027.2, which is the same batch as the sample tested by MCT. A report detailing the INL results is included in Appendix B of this report. INL found the saturated hydraulic conductivity of the reducing fill grout to be much lower than that measured by MCT on the three inch diameter samples. INL first attempted to determine the saturated hydraulic conductivity using a falling head method (Table 15). This was unsuccessful as the conductivity was found to be less than the limit for the method. Subsequently, INL used centrifugation to measure the saturated hydraulic conductivity of the reducing fill grout and found it to range from 4.0×10^{-10} to 9.0×10^{-11} cm/sec with an arithmetic average of 3.7×10^{-10} cm/sec. The bulk density of the reducing fill grout as reported by INL ranged from 1.81 to 1.84 g/cm^3 with an arithmetic average of 1.83 g/cm^3, which is comparable to that measured by MCT (Table 15). INL found the saturated porosity of the reducing fill grout to range from 0.264 to 0.272 with an arithmetic average 0.268, which is also comparable to that measured by MCT (Table 23).

One possible explanation for the difference between the INL and MCT results for the saturated hydraulic conductivity of the reducing fill grout could be leakage along the side of the sample in the permeameter. To rule out this possibility, four of the reducing fill grout samples were retested at a confining pressure of 40 psig (compared to 10 psig for the original tests). No significant difference was found in the conductivities of the samples upon retesting at the higher confining pressure. The average saturated hydraulic conductivity of the retested samples was 4.6×10^{-8} cm/sec. Therefore, it is unclear why the permeability for the reducing fill grout reported by INL is so much lower than that measured by MCT. Sample size can impact saturated hydraulic conductivity measurements, with smaller samples often resulting in lower measured conductivities, since they do not always represent the full range of heterogeneities that may be present in larger samples. Therefore, to be conservative, the INL data were excluded from establishing the recommended value for saturated hydraulic conductivity of the reducing grout.

Water retention properties of the reducing fill grout samples were determined by MCT and INL and are presented in Table 22 and Table 23. The MCT testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 22. A wafer approximately 3 inches in diameter and ½ inch thick from each sample was tested using a pressure plate apparatus. Water retention curves were prepared for each sample and are shown in Figure 3.

INL also measured the water retention characteristics of the reducing fill grout samples by testing sub-cores of the grout over a range of pressures from 0 to approximately 45,000 cm of H_2O (~45 bars). A combination of methods was used to establish the water retention curve including hanging column analysis (for the wet end of the curve), pressure plate apparatus (for the middle portion of the curve), and chilled mirror analysis (for the dry end of the curve). Water retention curves were prepared for each sample and are shown in Figure 4. It is noted that the drainage curves for the samples tested by INL are similar to the curves generated by MCT. A plot which combines the curves from MCT and INL is shown in Figure 5.

4.2.3 Alternative Reducing Fill Grout 1A Hydraulic and Physical Properties

Two samples of alternative grout mix 1A were tested by GTX to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 16 and summarized in Table 20. Sample details are given in Table 1. The samples were cured for a minimum of 28 days prior to shipping them to GTX for testing. Both samples came from the same batch of grout. The mix design for alternative grout mix 1A is presented in Table 4. The saturated hydraulic conductivity of this mix ranged from 8.2×10^{-9} to 9.5×10^{-9} cm/sec with an arithmetic average of 8.9×10^{-9} cm/sec. The dry bulk density of the alternative grout mix 1A ranged from 1.84 to 1.88 g/cm^3 with an arithmetic average of 1.86 g/cm^3. The water exchangeable porosity ranged from 0.190 to 0.250 with an arithmetic average of 0.220. The porosity of this mix is comparable to a low quality concrete (0.226). The WCMR for this mix (WCMR = 0.49) is comparable to ordinary concrete. Because this mix contains fly ash and blast furnace slag, the saturated hydraulic conductivity and porosity of this mix may decrease with increased curing time.

Water retention properties of alternative reducing fill grout 1A samples were determined by GTX and are presented in Table 24. The GTX testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 24. Two wafers approximately 3 inches in diameter and ½ inch thick from each sample were tested using a pressure plate apparatus. The wafers were taken from the top and the bottom of the mold sample. Water retention curves were prepared for each sample and are shown in Figure 6.

4.2.4 Alternative Reducing Fill Grout 1B Hydraulic and Physical Properties

Four samples of alternative grout mix 1B were tested also tested by GTX to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 17 and summarized in Table 20. Sample details are given in Table 1. The samples were cured for a minimum of 28 days prior to shipping them to GTX for testing. All four samples came from the same batch of grout. The mix design for alternative grout mix 1B is presented in Table 5. The saturated hydraulic conductivity of this mix ranged from 1.0×10^{-8} to 1.5×10^{-8} cm/sec with an arithmetic average of 1.3×10^{-8} cm/sec. The dry bulk density of the alternative grout mix 1B ranged from 1.82 to 1.86 g/cm^3 with an arithmetic average of 1.85 g/cm^3. The water exchangeable porosity ranged from 0.230 to 0.250 with an arithmetic average of 0.240. The porosity of this mix is slightly greater than that of a low quality concrete (0.226). For this mix, the WCMR was 0.37, which is a relatively low WCMR. Because this mix contains fly ash and blast furnace slag, the saturated hydraulic conductivity and porosity of this mix may decrease with increased curing time.

Water retention properties of alternative reducing fill grout 1B samples were determined by GTX and are presented in Table 25. The GTX testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 25. Two wafers approximately 3 inches in diameter and ½ inch thick from each sample were tested using a pressure plate apparatus. The wafers were taken from the top and the bottom of the mold sample. Water retention curves were prepared for each sample and are shown in Figure 7.

4.2.5 Alternative Reducing Fill Grout 2 Hydraulic and Physical Properties

Four samples of alternative grout mix 2 were also tested by MCT to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 17 and summarized in Table 20. Sample details are given in Table 1. The samples were cured for a minimum of 28 days prior to shipping them to GTX for testing. All four samples came from the same batch of grout. The mix design for alternative grout mix 2 is presented in Table 6 The saturated hydraulic conductivity of this mix ranged from 5.5 x 10^{-9} to 8.1 x 10^{-9} cm/sec with an arithmetic average of 6.6 x 10^{-9} cm/sec. The dry bulk density of the alternative grout mix 2 ranged from 1.92 to 2.06 g/cm^3 with an arithmetic average of 1.96 g/cm^3. The water exchangeable porosity ranged from 0.186 to 0.225 with an arithmetic average of 0.209. The porosity of this mix is slightly less than that of a low quality concrete (0.226). For this mix, the WCMR was 0.39, which is a relatively low WCMR. Because this mix contains fly ash and blast furnace slag, the saturated hydraulic conductivity and porosity of this mix may decrease with increased curing time.

Water retention properties of alternative reducing fill grout 2 samples were determined by MCT and are presented in Table 26. The MCT testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 26. A wafer approximately 3 inches in diameter and ½ inch thick from each sample was tested using a pressure plate apparatus. Water retention curves were prepared for each sample and are shown in Figure 8.

4.2.6 Base Mat Surrogate Hydraulic and Physical Properties

Four samples of a surrogate for the base mat concrete were tested by GTX to estimate the hydraulic and physical properties of the grout. The results of this testing are presented in Table 19 and summarized in Table 20. Sample details are given in Table 1. The base mat surrogate concrete samples were taken from the concrete pad within the P-Area Retention Basin (904-86G). The saturated hydraulic conductivity of the base mat surrogate concrete ranged from 1.6 x 10^{-8} to 6.0 x 10^{-8} cm/sec with an arithmetic average of 3.4 x 10^{-8} cm/sec. The dry bulk density of the base mat surrogate concrete ranged from 2.01 to 2.14 g/cm^3 with an arithmetic average of 2.06 g/cm^3. The water exchangeable porosity ranged from 0.150 to 0.190 with an arithmetic average of 0.168.

Water retention properties of the base mat surrogate samples were determined by GTX. The GTX testing was conducted at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 21. Two wafers approximately 3 inches in diameter and ½ inch thick from each sample were tested using a pressure plate apparatus. The wafers were taken from the top and the bottom of the core sample. Water retention curves were prepared for each sample and are shown in Figure 9.

4.3 ANALYSIS OF WATER RETENTION DATA

The measured water retention data were analyzed using the RETC code (USDA, 1998) to determine the van Genuchten transport parameters and the relative hydraulic conductivity function for each tank grout and the base mat surrogate. For each material type, the "average" was calculated by arithmetically averaging the saturation values (S) of the individual water retention measurements at each suction value. For materials where wafers were tested from the top and bottom of the sample, an average curve was determined separately for the top and bottom samples. The water retention results were averaged (rather than allowing RETC to generate a curve based on all of the raw data) to create a fitted curve more representative of the average of the individual curves. Results from the analysis are presented in Table 28 and are shown in Figure 10 through Figure 21. All parameters in the RETC model were fitted except for saturated water content (θ_s). The saturated water content was set to the average vacuum saturated water content for each material. All moisture retention values were given a weight of 1. The standard Mualem relationship between n and m (i.e., m = 1 – 1/n) was used. In general, good agreement between the measured data and the fitted retention curves was observed ($r^2 >$ 0.99 for each case) for each material.

The characteristic curves for the strong grout are shown in Figure 10. These curves were based upon water retention data through 5,103.5 cm H_2O (5 bars) due to a delay in receiving data from MCT. However, Figure 10 shows the curve fit is adequate.

The characteristic curves for the reducing fill grout are shown in Figure 11. These curves were also based upon water retention data through 5,103.5 cm H_2O (5 bars) due to a delay in receiving data from MCT. However, Figure 11 shows the curve fit is adequate.

INL used the moisture retention data from TNK019R and TNK020R to develop the van Genuchten transport parameter for the grout sub-cores. These results are presented in Figure 12 and Figure 13 and Table 28. For comparison, the characteristic curves generated by INL for the reducing fill grout are plotted together with those determined using the MCT data in Figure 14. The results produced by both labs are comparable. INL was able to obtain water retention data beyond the 15 bar maximum suction head of MCT. This may illustrate the importance of water retention data at high suction heads for cementitious materials.

The characteristic curves for the three alternative fill grouts are shown in Figure 15 through Figure 19. Of the three alternative grouts, alternative fill grout 2 exhibited the best drainage characteristics. Alternative fill grout 2 drained to about 85 percent saturation at a suction head of 15 bars. Alternative fill grout 1A and alternative fill grout 1B drained to 60 and 70 percent saturation, respectively.

The characteristic curves for the base mat surrogate are shown in Figure 20 and Figure 21. These figures show the base mat surrogate to have drainage properties similar to a soil material. A review of the CT scans for this material (see Section 4.4) showed significant interconnected macro-porosity and poor cementation at the aggregate-paste boundary (Figure 29). These attributes would likely cause the base mat surrogate to exhibit drainage characteristics similar to a soil material at least until the macro-porosity had been drained.

4.4 TOMOGRAPHIC ANALYSIS OF TANK GROUTS AND BASE MAT SURROGATE SAMPLES

Selected samples of each tank grout and base mat surrogate were scanned using computed tomography (CT) to examine the internal structure of the samples and to make qualitative observations regarding connected porosity and preferential flow paths or channels within each sample. Tomographic reconstructions perpendicular and longitudinal to the cylindrical axis were used to provide cross sectional and transverse views. These scans were prepared to show pores, cracks, voids, aggregate, and the cementitious matrix as well as other internal features in the samples.

Images from these scans for the tank grout and the base mat surrogate are shown in Figure 24 through Figure 32. With the exception of the base mat surrogate, these figures show the samples from each mix to be relatively homogeneous with very little interconnected macro-porosity. The observed macro-porosity (represented by black features within the samples) is minimal and does not appear to be connected. No macro channels are observed in any of the images. These findings are consistent with the low saturated hydraulic conductivity values measured for each mix. For the base mat surrogate (Figure 29), poor cementation around a portion of the aggregate-paste interface is observed which could produce channels or preferential flow paths. The observed channeling does not appear to run the entire length of the core and so long as any channeling is localized it would not be expected to greatly influence the saturated hydraulic conductivity of the material. This is reflected in the relatively low saturated hydraulic conductivity measurements for the mix (average of 3.4×10^{-8} cm/sec)

5.0 SUMMARY

The primary focus of this task was to measure the physical and hydraulic properties of various FTF tank grouts and a base mat surrogate concrete. These materials included 1) strong grout B2000-X-0-0-BS (WSRC, 2003), 2) reducing fill grout OPDEXE-X-P-0-BS (WSRC, 2003), 3) Alternative reducing fill grout 1A (Ganguly and Langton, 2007), 4) Alternative reducing fill grout 1B (Ganguly and Langton, 2007), 5) Alternative reducing fill grout 2 (Ganguly and Langton, 2007), and 6) Base mat surrogate (provided by SRIP).

Three inch diameter mold samples of each material (except the base mat surrogate) were prepared at the site concrete testing facility located in N-Area and allowed to cure for a minimum of 28 days in a controlled environment (Ganguly and Langton, 2007). Cores of the base mat surrogate approximately 3 inches in diameter were taken from concrete in the P-Area Retention Basin (904-86G). These concrete core samples were intended to be representative of Class 3 concrete (DuPont Specification 5B 6 A for 3000 psig concrete) poured at SRS during the 1950s or 1960s.

The mold samples, along with the base mat surrogate samples, were submitted to offsite laboratories for testing of hydraulic and physical properties. These services were provided by MACTEC Engineering and Consulting, Inc (MCT) and Geotesting Express, Inc. (GTX) per ASTM standard methods. Properties measured included saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity. Idaho National Laboratory (INL) was also contracted to test samples of the reducing fill grout. INL used a steady state centrifugation-unsaturated flow apparatus (SSC-UFA) to measure the hydraulic properties of the reducing fill grout. Using the SSC-UFA, INL measured the saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity of the reducing fill grout. Due to the low saturated hydraulic conductivity of the reducing fill grout, INL was unable to directly measure the unsaturated hydraulic conductivity as a function of moisture content. Recommended hydraulic properties for each tank grout and the base mat surrogate are presented in Table 29 and are based upon the testing conducted by MCT, GTX, and INL.

Water retention data were analyzed using the RETC code (USDA, 1998) to determine the van Genuchten transport parameters and the relative hydraulic conductivity function for each tank grout and the base mat surrogate. These parameters may be used to implicitly determine the relationship between unsaturated hydraulic conductivity and moisture content. The recommended van Genuchten transport parameters for each tank grout and the base mat surrogate are presented in Table 30. For the strong grout and alternative fill grout 2, these parameters are the same as those shown in Table 28. For the reducing fill grout, the transport parameters determined by INL were averaged and then those values were averaged with the parameters determined using the MCT data. For alternative fill grout 1A, alternative fill grout 1B, and the base mat surrogate, the recommended parameters are the average of the parameters determined from the top and bottom samples for each mix (as presented in Table 28).

Figure 22 shows a plot of the recommended characteristic curves for each of the FTF tank grouts and the base mat surrogate concrete. Figure 23 shows a plot of the recommended characteristic curves for the reducing fill grout and the base mat surrogate separately. Appendix D provides a summary of the recommended characteristic curves for the tank grouts and the base mat surrogate.

Tomographic scans were made of selected samples from each of the tank grouts and base mat surrogate. These scans showed the internal structure of each sample and provided a qualitative perspective of the macro-porosity of each sample. These images showed very little heterogeneity and interconnected macro-porosity in the tank grouts. There appeared to be more interconnected macro-porosity in the base mat surrogate sample particularly along the aggregate paste boundary.

6.0 REFERENCES

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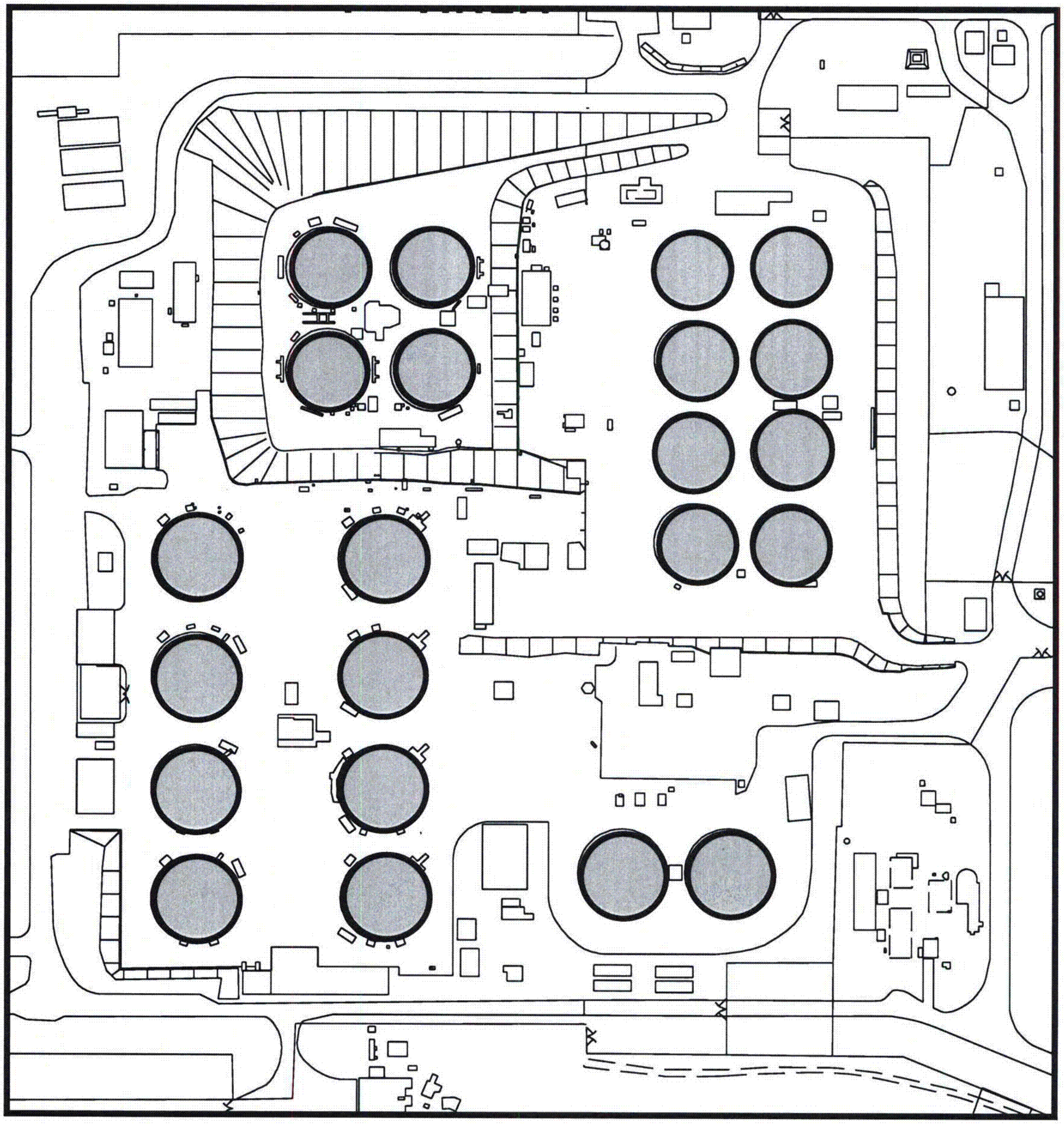


Figure 1. General Layout of the FTF.

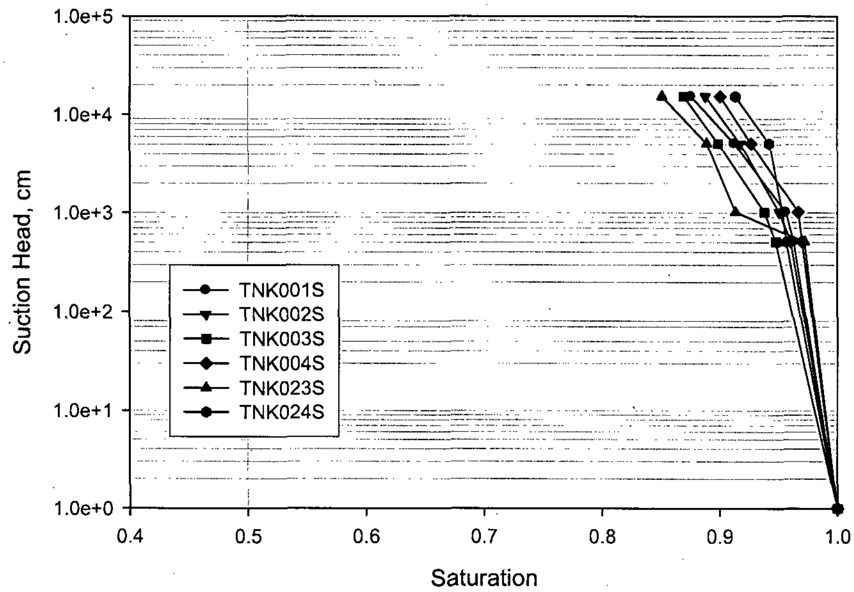


Figure 2. Water retention curves for the strong grout (B2000-X-0-0-BS) as measured by MCT.

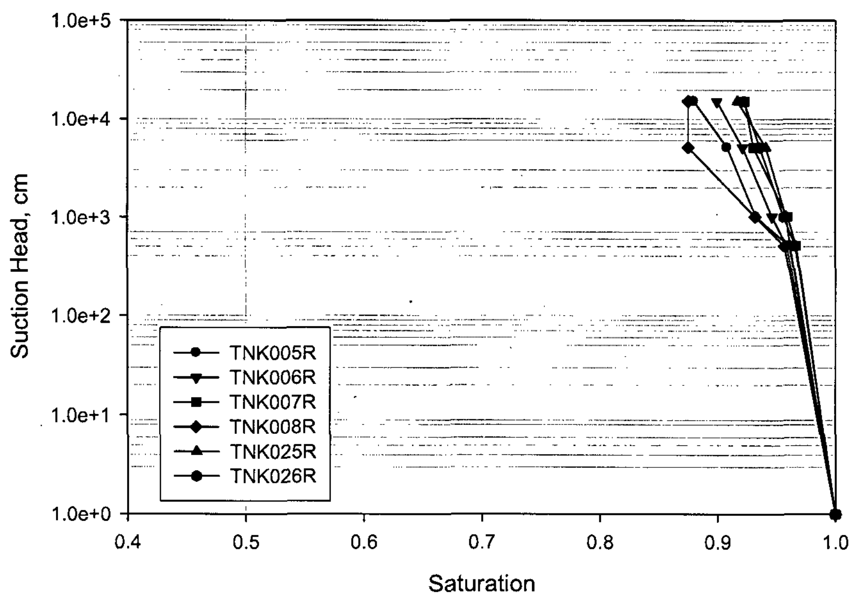


Figure 3. Water retention curves for the reducing fill grout (OPDEXE-X-P-0-BS) as measured by MCT.

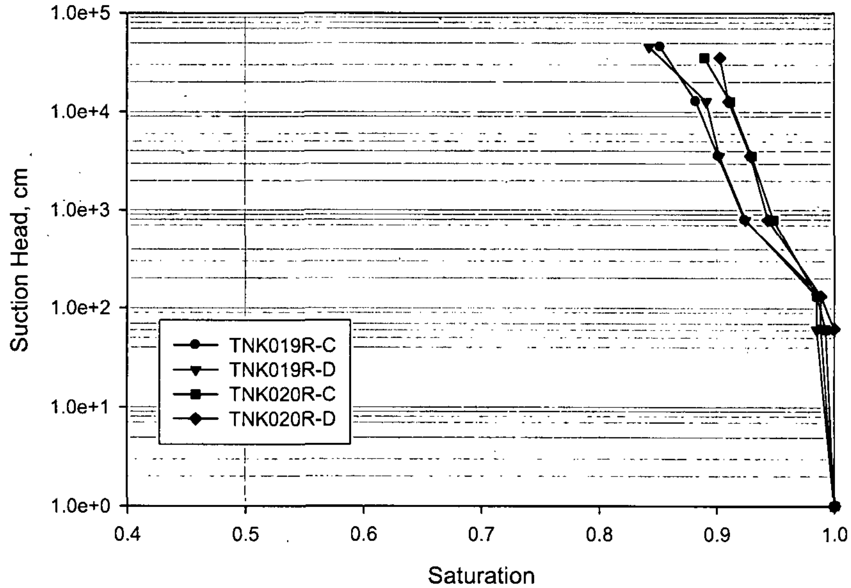


Figure 4. Water retention curves for the reducing fill grout (OPDEXE-X-P-0-BS) as measured by INL.

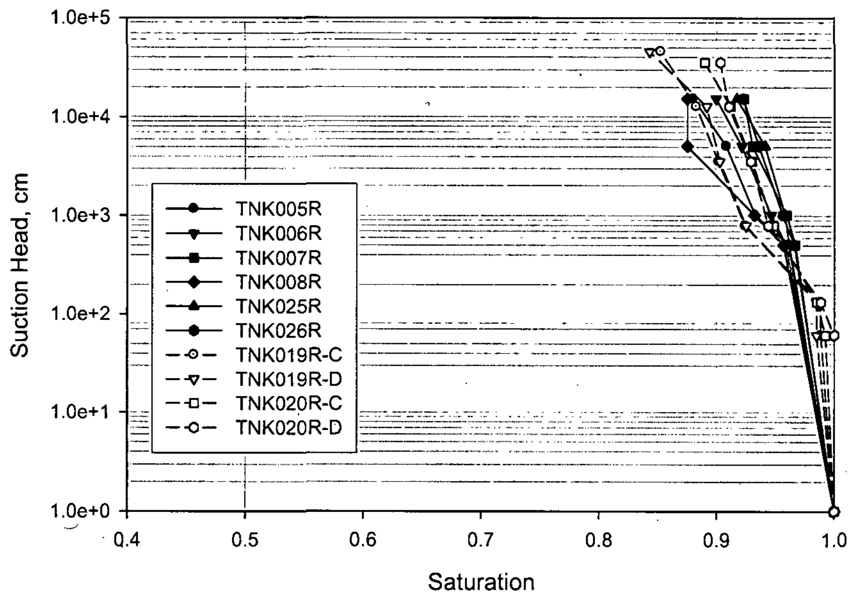


Figure 5. Combined water retention curves for the reducing fill grout (OPDEXE-X-P-0-BS) as measured by MCT and INL. TNK019R-C, TNK019R-D, TNK020R-C, and TNK020R-D were measured by INL.

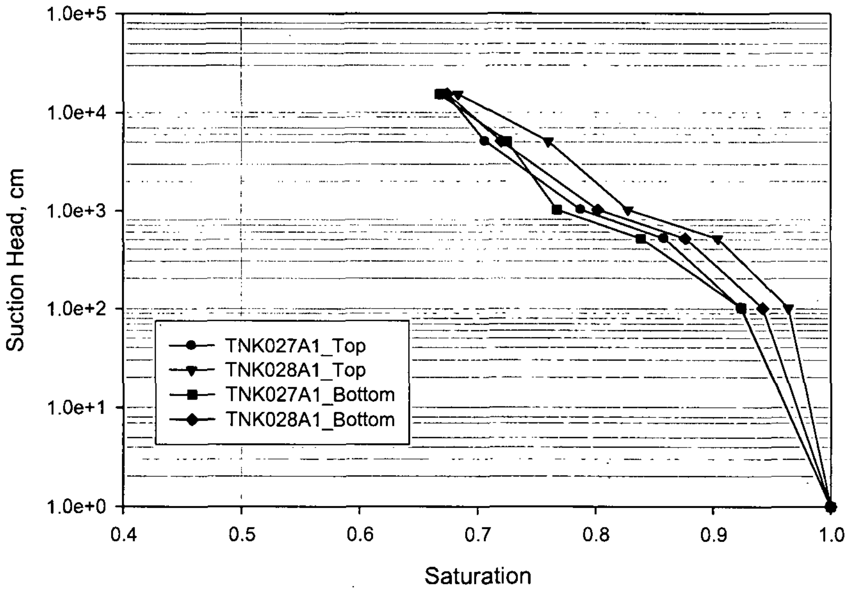


Figure 6. Water retention curves for alternative reducing fill grout 1A as measured by GTX.

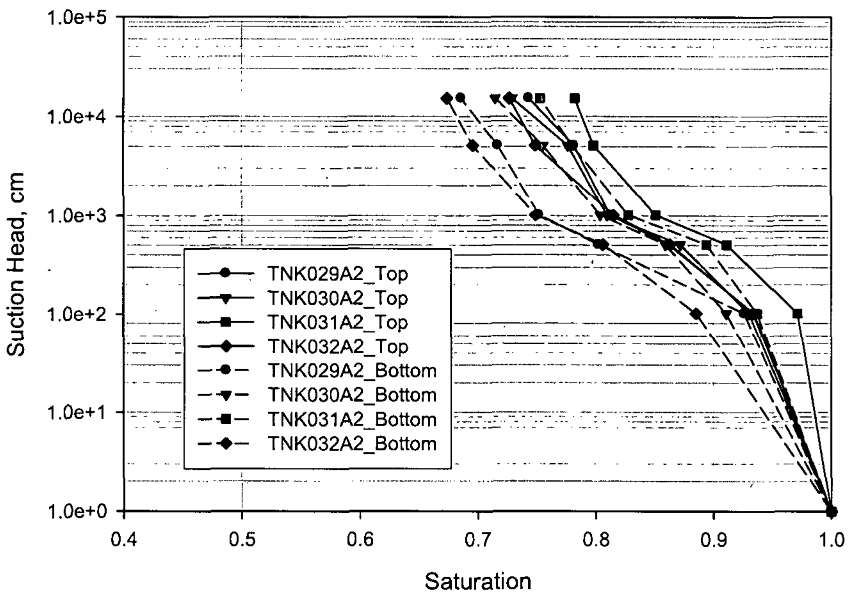


Figure 7. Water retention curves for alternative reducing fill grout 1B as measured by GTX.

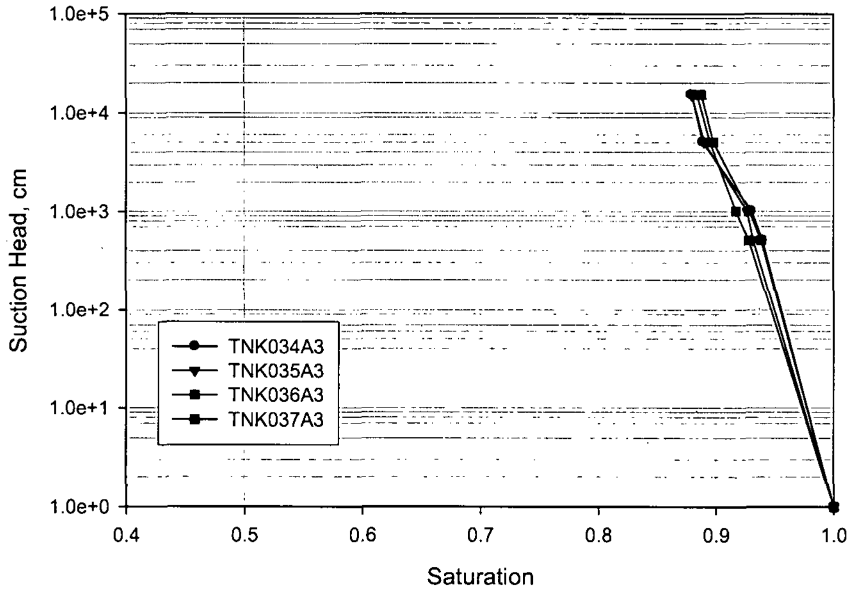


Figure 8. Water retention curves for alternative reducing fill grout 2 as measured by GTX.

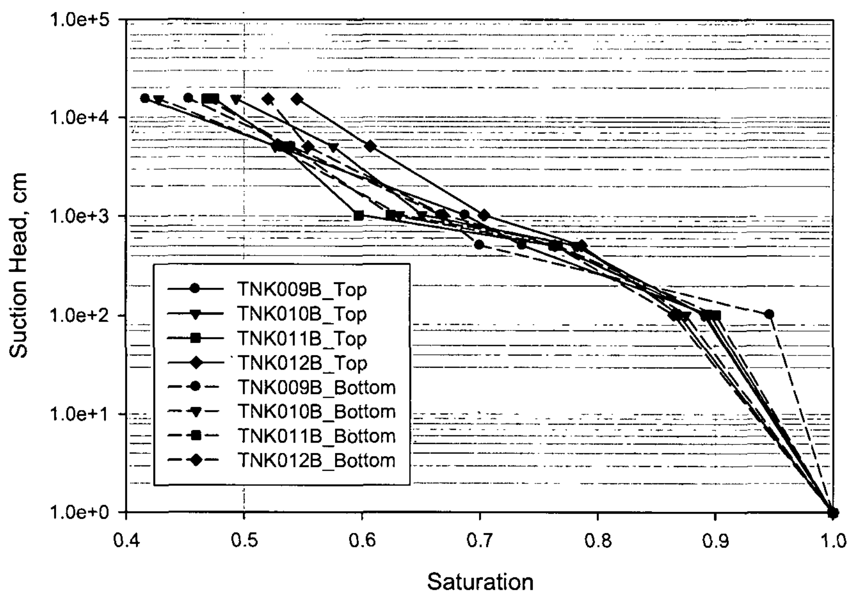


Figure 9. Water retention curves for the base mat surrogate as measured by GTX.

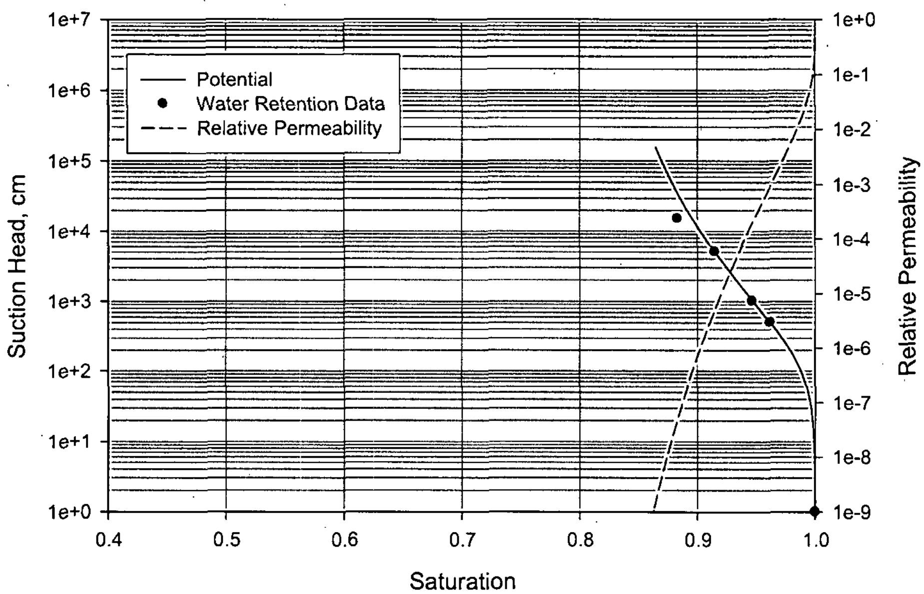


Figure 10. Characteristic curves for the strong grout (B2000-X-0-0-BS).

(Characteristic curves based on water retention data through 5 bars.)

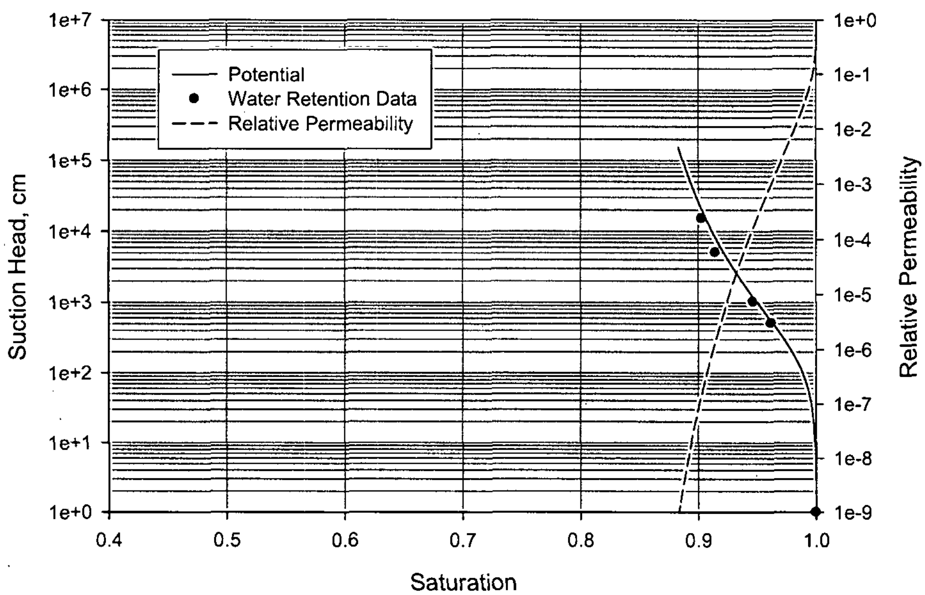


Figure 11. Characteristic curves for the reducing fill grout (OPDEXE-X-P-0-BS) as determined from MCT data.

(Characteristic curves based on water retention data through 5 bars.)

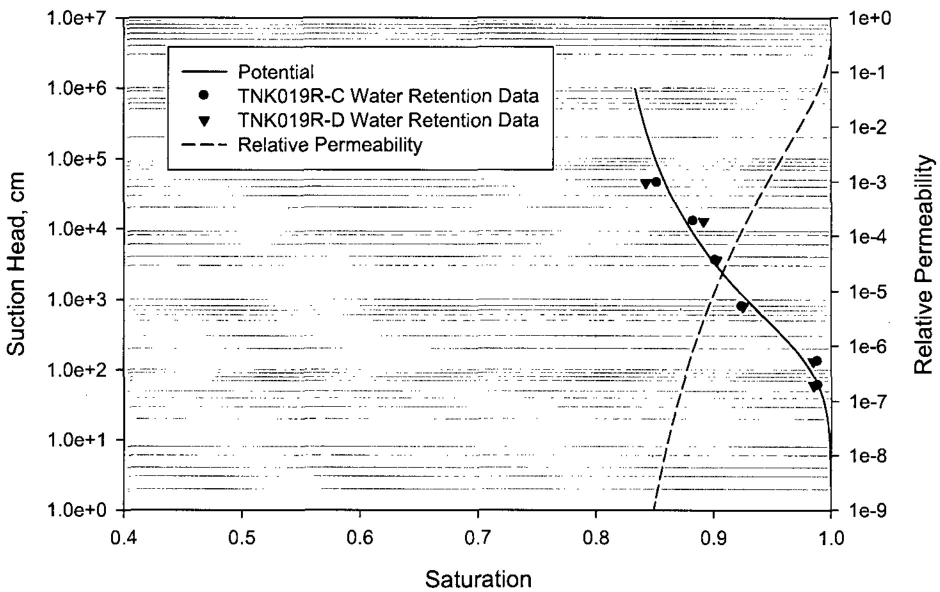


Figure 12. Characteristic curves for the reducing fill grout sample TNK019R (OPDEXE-X-P-0-BS) as determined by INL.

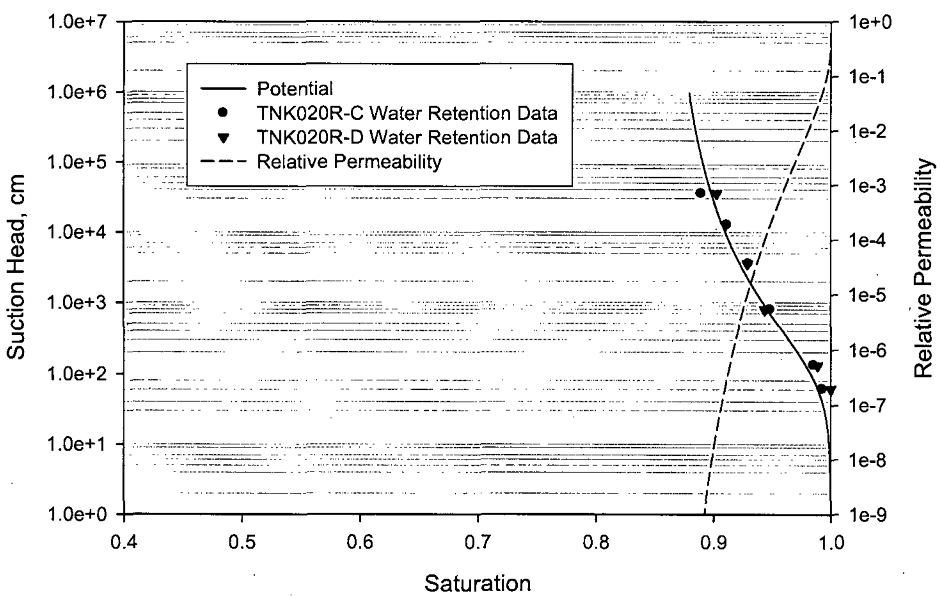


Figure 13. Characteristic curves for the reducing fill grout sample TNK020R (OPDEXE-X-P-0-BS) as determined by INL.

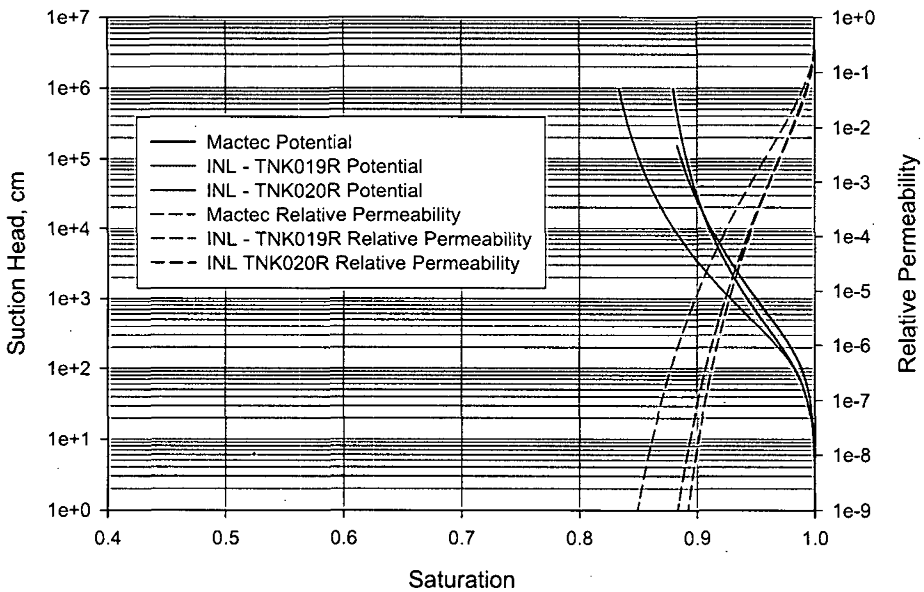


Figure 14. Comparison of characteristic curves for the reducing fill grout (OPDEXE-X-P-0-BS) as determined from the MCT and INL data.

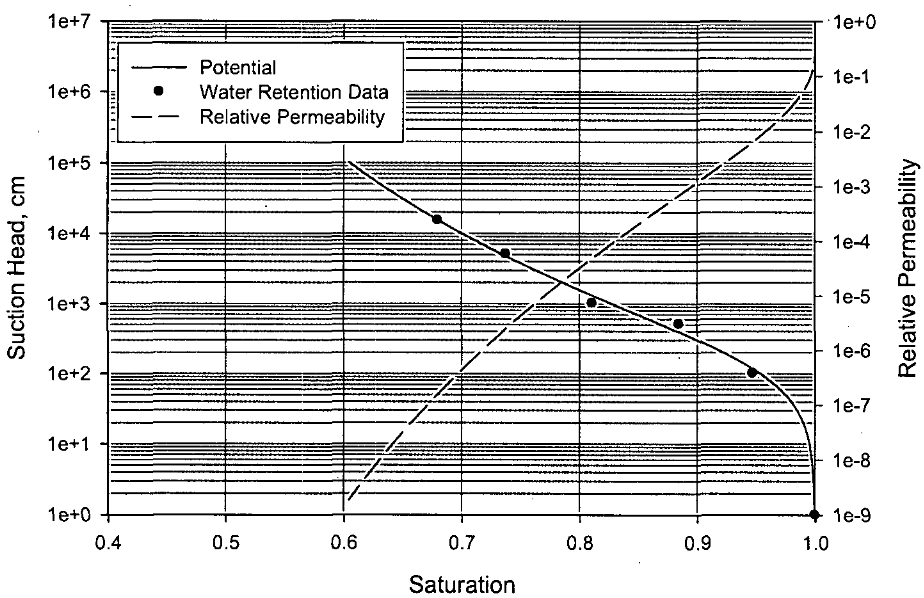


Figure 15. Characteristic curves for alternative reducing fill grout 1A (top samples).
(Water retention data average of samples TNK027A1_Top and TNK028A1_Top)

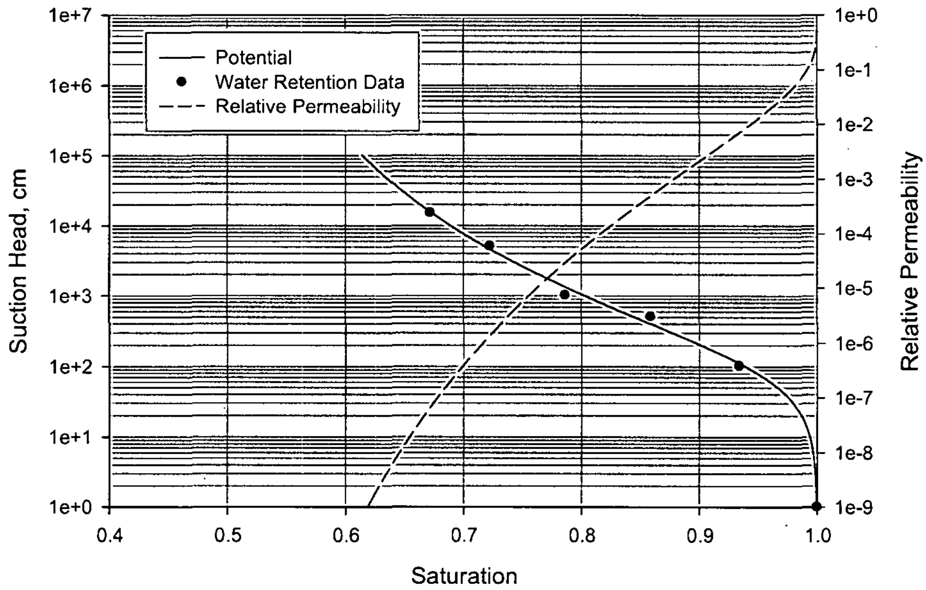


Figure 16. Characteristic curves for alternative reducing fill grout 1A (bottom samples).

(Water retention data average of samples TNK027A1_Bottom and TNK028A1_Bottom)

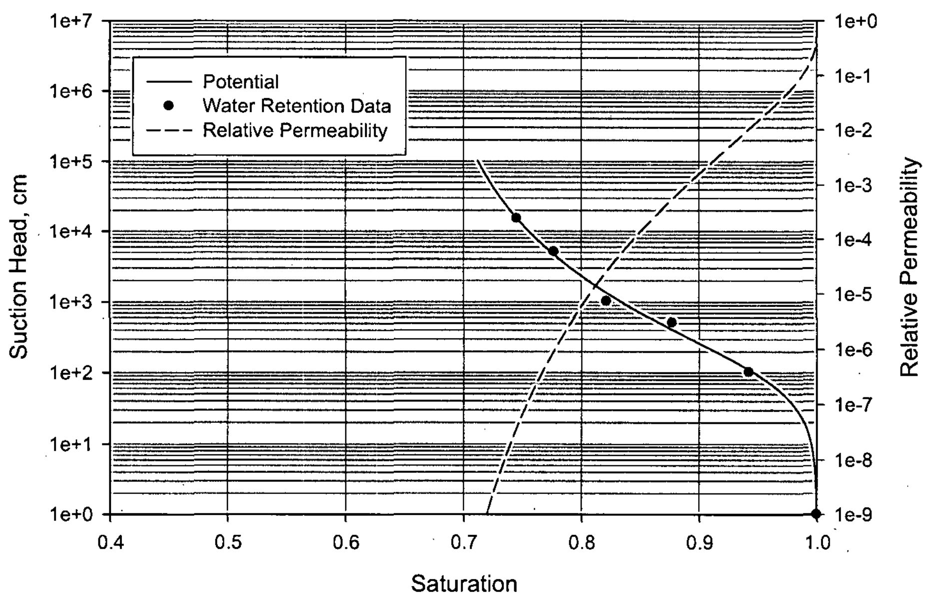


Figure 17. Characteristic curves for alternative reducing fill grout 1B (top samples).

(Water retention data average of samples TNK029A2_Top, TNK030A2_Top, TNK031A2_Top, and TNK032A2_Top)

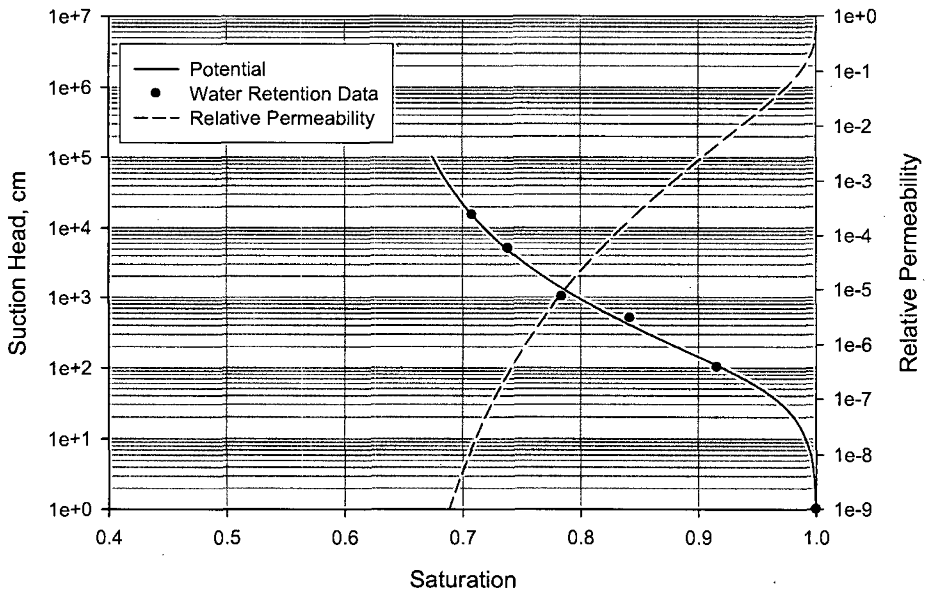


Figure 18. Characteristic curves for alternative reducing fill grout 1B (bottom samples).

(Water retention data average of samples TNK029A2_Bottom, TNK030A2_ Bottom, TNK031A2_ Bottom, and TNK032A2_ Bottom)

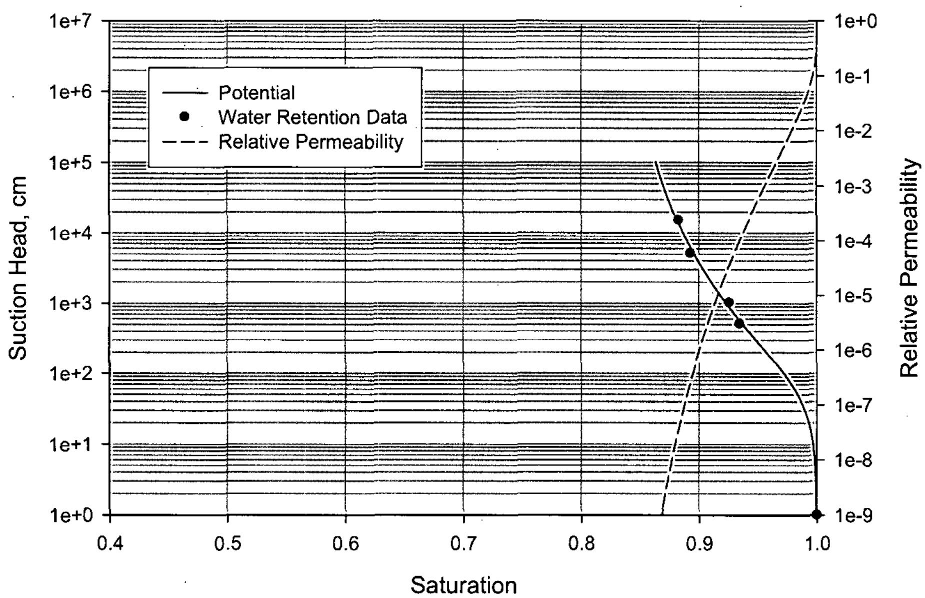


Figure 19. Characteristic curves for alternative reducing fill grout 2.

(Water retention data average of samples TNK034A3, TNK035A3, TNK036A3,and TNK037A3)

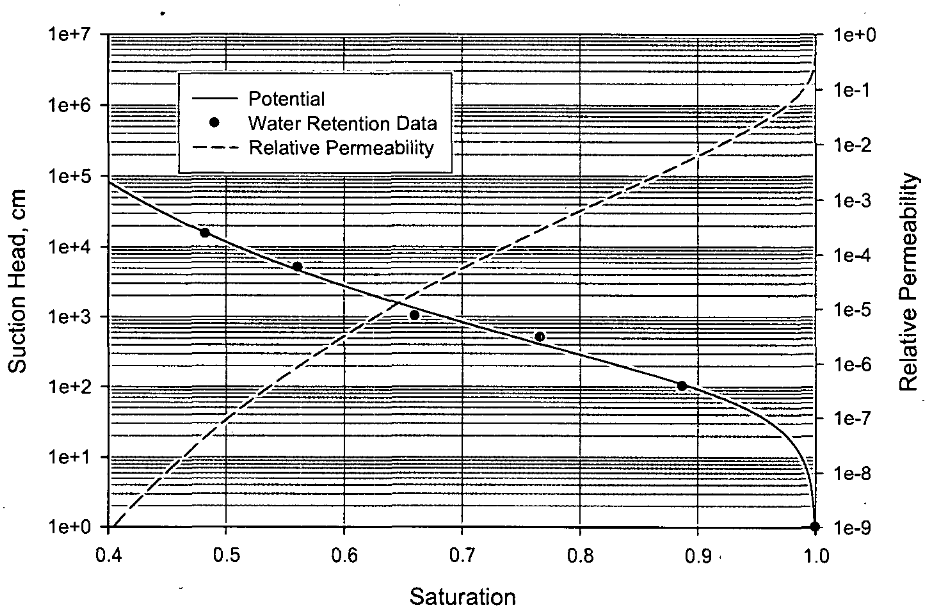


Figure 20. Characteristic curves for the base mat surrogate (top samples).

(Water retention data average of samples TNK009B_Top, TNK010B_Top, TNK011B_Top, and TNK012B_Top)

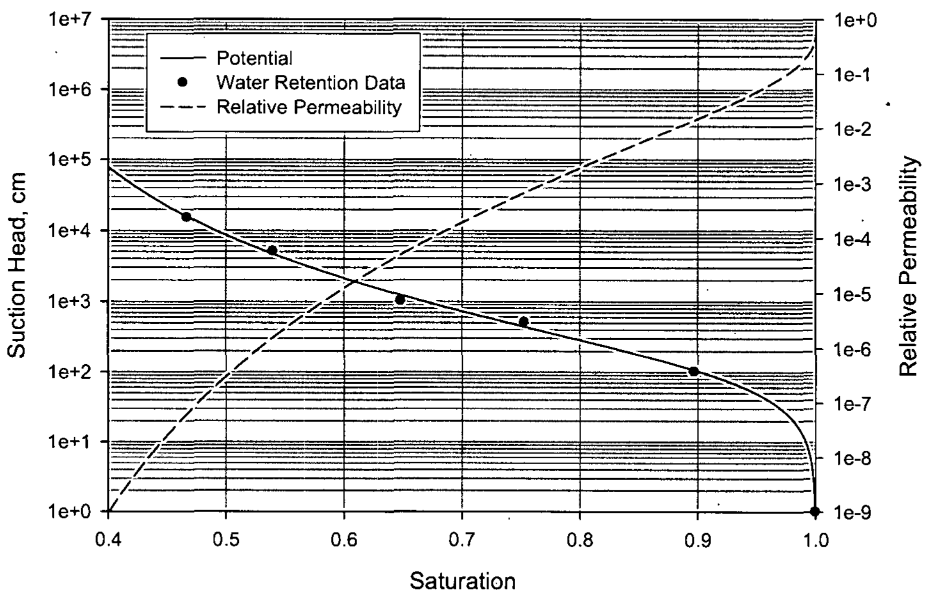


Figure 21. Characteristic curves for the base mat surrogate (bottom samples).

(Water retention data average of samples TNK009B_Bottom, TNK010B_Bottom, TNK011B_Bottom, and TNK012B_Bottom)

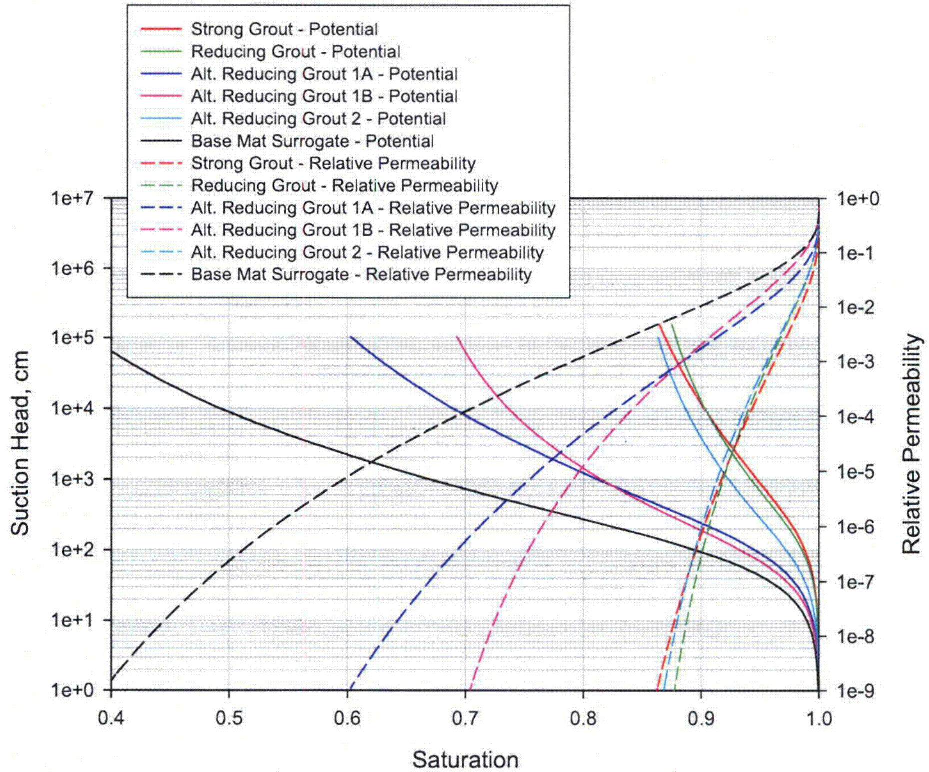


Figure 22. Recommended characteristic curves for FTF tank grouts and base mat surrogate.

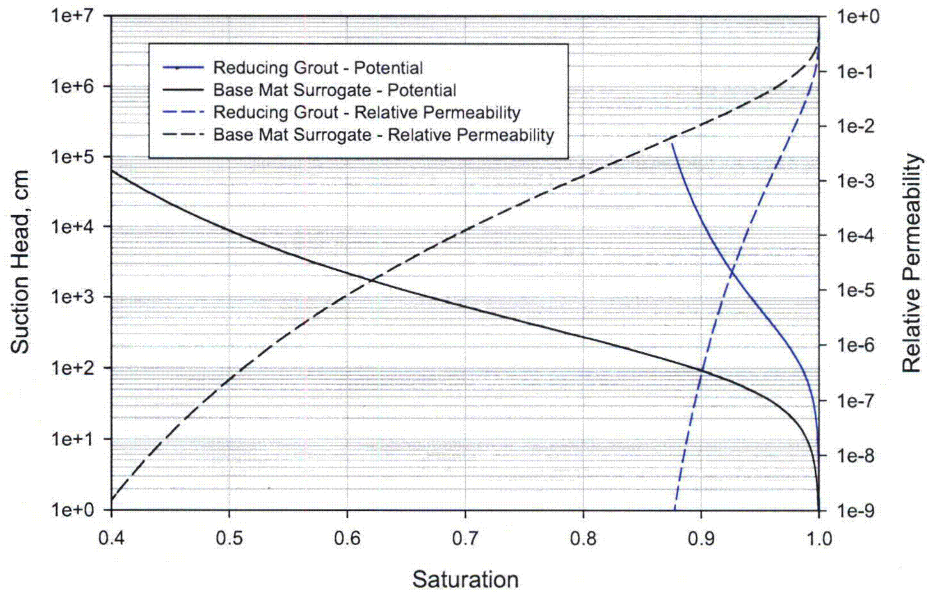
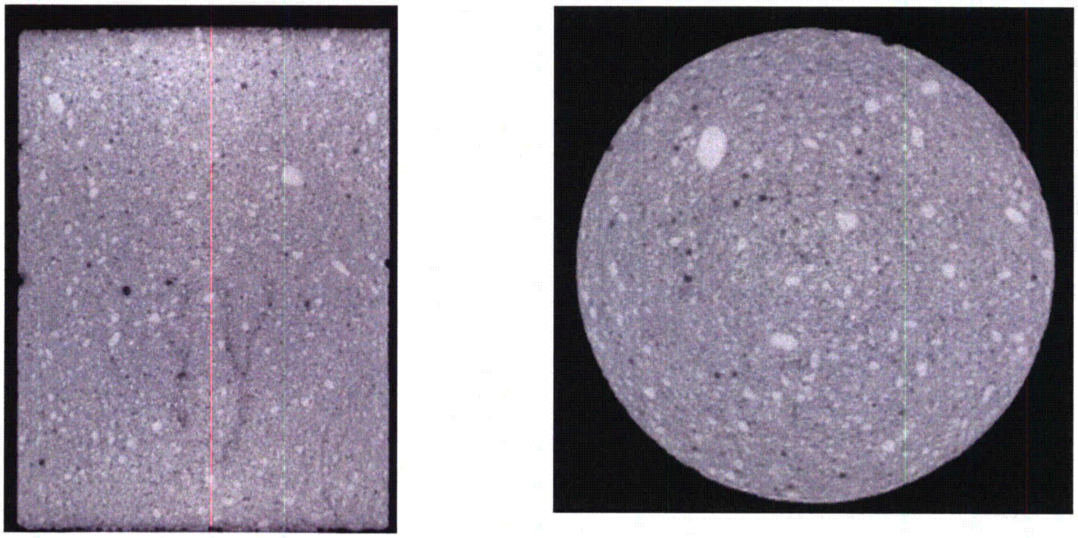
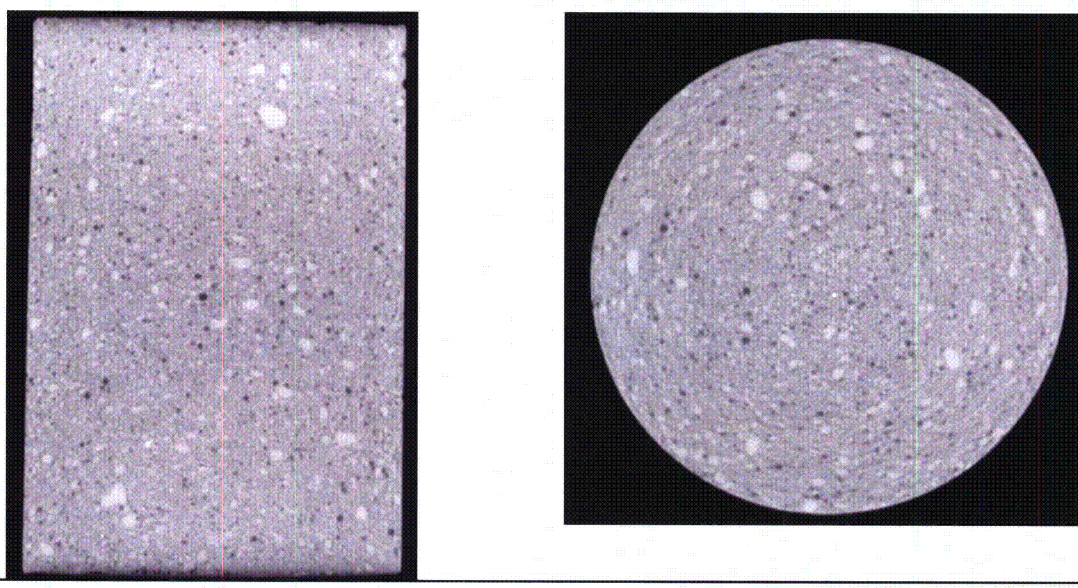


Figure 23. Recommended characteristic curves for reducing fill grout (OPDEXE-X-P-0-BS) and base mat surrogate.



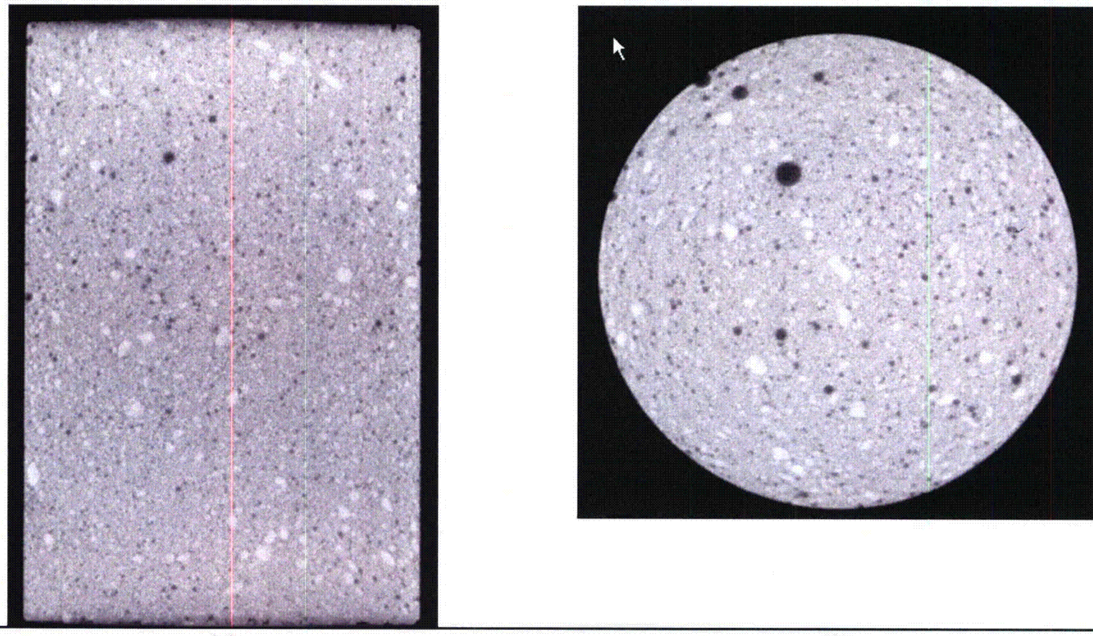
(a) (b)

Figure 24. Longitudinal (a) and transverse (b) slice of three inch diameter strong grout mold sample TNK001S. Macro-porosity is represented by black features ($K_s = 2.8x10^{-8}$ cm/sec).



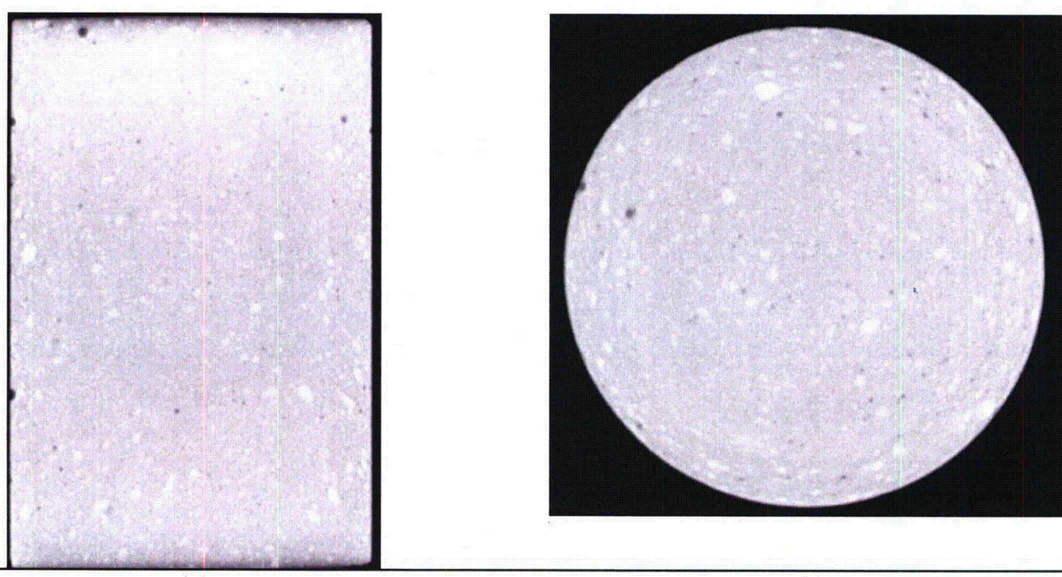
(a) (b)

Figure 25. Longitudinal (a) and transverse (b) slice of three inch diameter strong grout mold sample TNK023S. Macro-porosity is represented by black features ($K_s = 6.8x10^{-9}$ cm/sec).



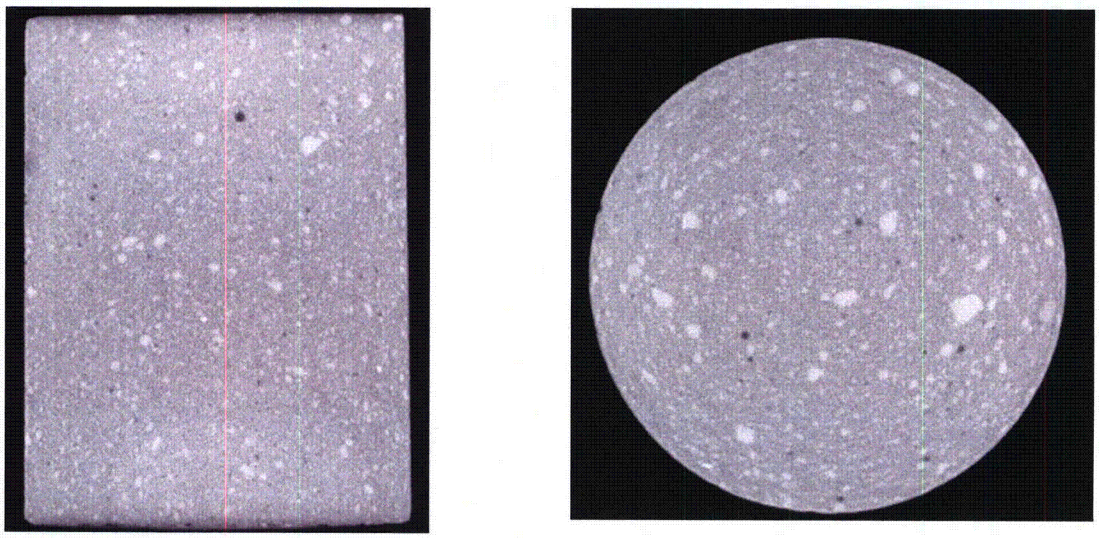
(a) (b)

Figure 26. Longitudinal (a) and transverse (b) slice of three inch diameter strong grout mold sample TNK024S. Macro-porosity is represented by black features ($K_s = 2.7x10^{-8}$ cm/sec).



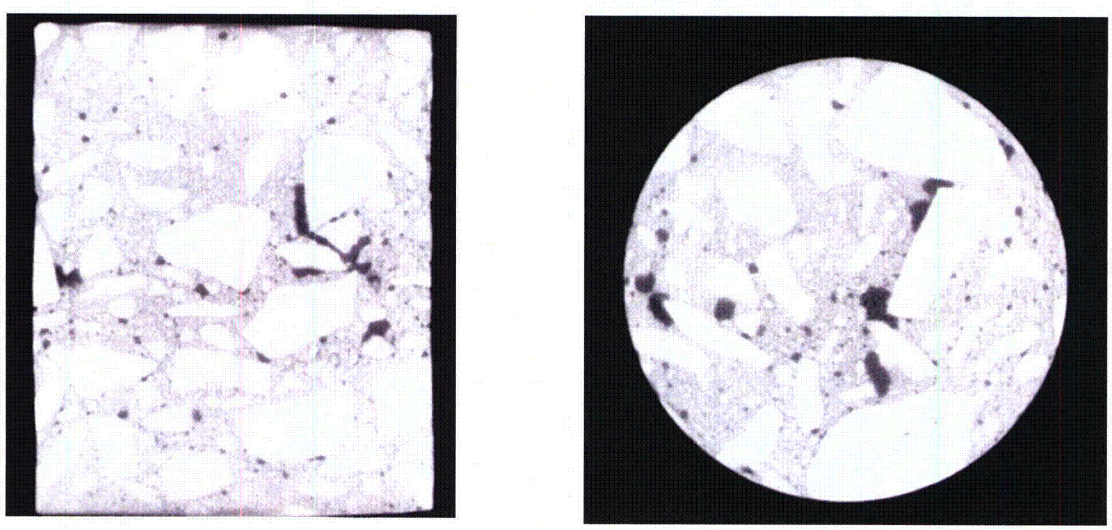
(a) (b)

Figure 27. Longitudinal (a) and transverse (b) slice of three inch diameter reducing fill grout mold sample TNK005R. Macro-porosity is represented by black features ($K_s = 1.0x10^{-8}$ cm/sec).



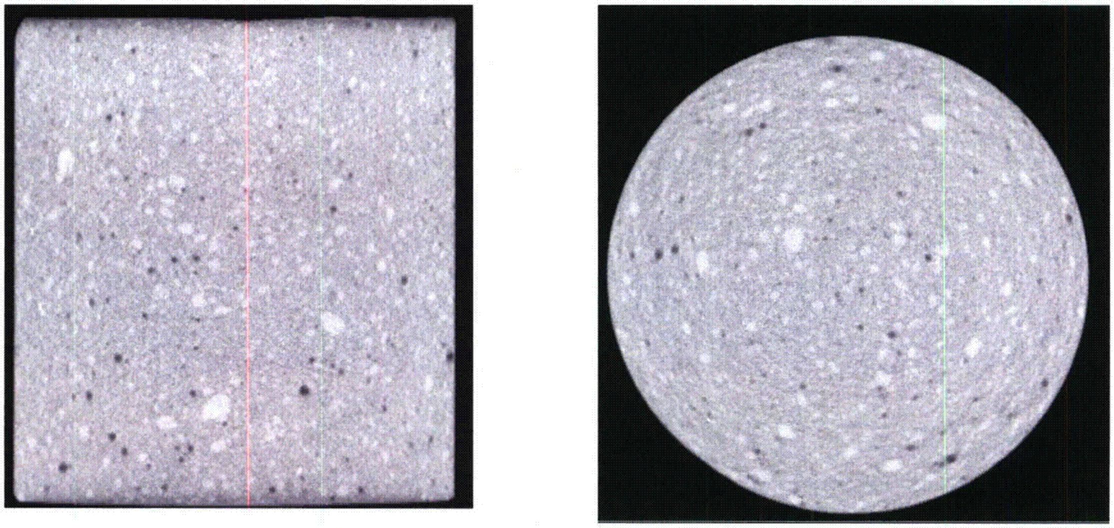
(a) (b)

Figure 28. Longitudinal (a) and transverse (b) slice of three inch diameter reducing fill grout mold sample TNK025R. Macro-porosity is represented by black features ($K_s = 4.3x10^{-8}$ cm/sec).



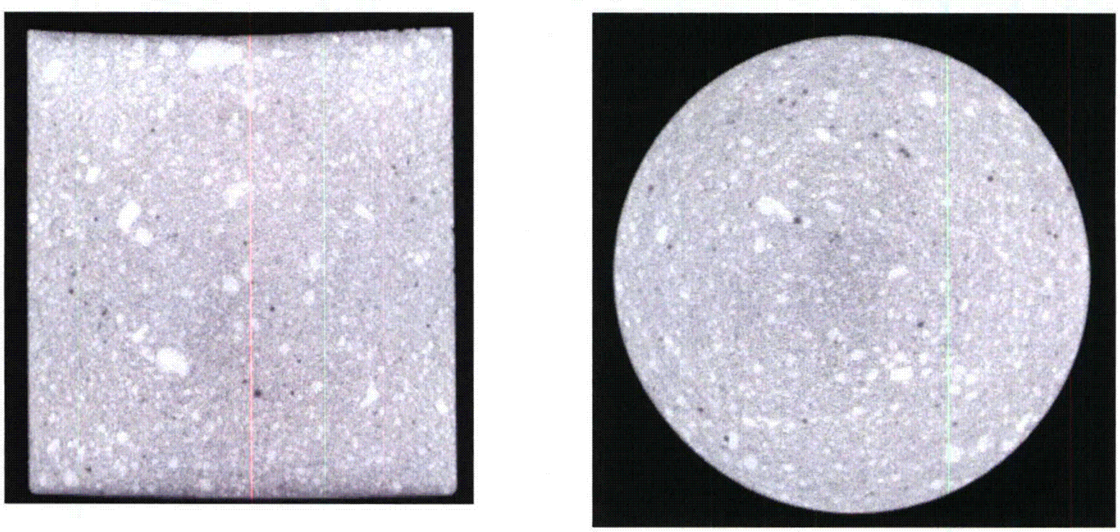
(a) (b)

Figure 29. Longitudinal (a) and transverse (b) slice of three inch diameter base mat surrogate core sample TNK009B. Macro-porosity is represented by black features ($K_s = 1.6x10^{-8}$ cm/sec).



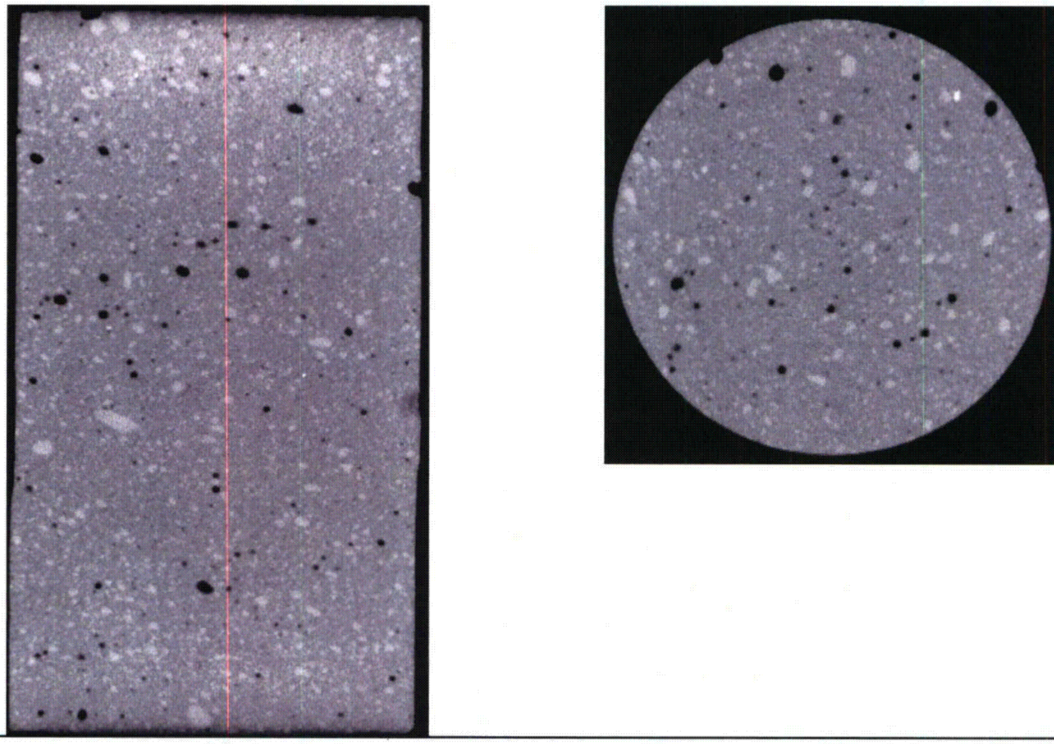
(a) (b)

Figure 30. Longitudinal (a) and transverse (b) slice of three inch diameter alternative reducing fill grout 1A mold sample TNK027A1. Macro-porosity is represented by black features ($K_s = 8.2 \times 10^{-9}$ cm/sec).



(a) (b)

Figure 31. Longitudinal (a) and transverse (b) slice of three inch diameter alternative reducing fill grout 1B mold sample TNK029A2. Macro-porosity is represented by black features ($K_s = 1.0 \times 10^{-8}$ cm/sec).



(a) (b)

Figure 32. Longitudinal (a) and transverse (b) slice of three inch diameter alternative reducing fill grout 2 mold sample TNK034A3. Macro-porosity is represented by black features ($K_s = 6.3x10^{-9}$ cm/sec).

Table 1. Sample Details for Tank Grout and Base Mat Surrogate Concrete Testing.

Sample_ID	Date Cast	Diameter (inches)	Type	Lab	Material	Batch ID
TNK001S	2/21/2007	3	Mold	MCT[1]	Strong Grout	070025.2
TNK002S	2/21/2007	3	Mold	MCT	Strong Grout	070025.2
TNK003S	2/21/2007	3	Mold	MCT	Strong Grout	070025.2
TNK004S	2/21/2007	3	Mold	MCT	Strong Grout	070025.2
TNK005R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK006R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK007R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK008R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK009B	3/30/2007	3	Core	GTX[2]	Base Mat Surrogate	NA
TNK010B	3/30/2007	3	Core	GTX	Base Mat Surrogate	NA
TNK011B	3/30/2007	3	Core	GTX	Base Mat Surrogate	NA
TNK012B	3/30/2007	3	Core	GTX	Base Mat Surrogate	NA
TNK019R	2/22/2007	1	Mold	INL[3]	Reducing Fill Grout	070027.2
TNK020R	2/22/2007	1	Mold	INL	Reducing Fill Grout	070027.2
TNK023S	2/21/2007	3	Mold	MCT	Strong Grout	070025.1
TNK024S	2/21/2007	3	Mold	MCT	Strong Grout	070025.1
TNK025R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK026R	2/22/2007	3	Mold	MCT	Reducing Fill Grout	070027.2
TNK027A1	3/28/2007	3	Mold	GTX	Alt Reducing Fill Grout 1A	070044
TNK028A1	3/28/2007	3	Mold	GTX	Alt Reducing Fill Grout 1A	070044
TNK029A2	3/21/2007	3	Mold	GTX	Alt Reducing Fill Grout 1B	070043
TNK030A2	3/21/2007	3	Mold	GTX	Alt Reducing Fill Grout 1B	070043
TNK031A2	3/21/2007	3	Mold	GTX	Alt Reducing Fill Grout 1B	070043
TNK032A2	3/21/2007	3	Mold	GTX	Alt Reducing Fill Grout 1B	070043
TNK034A3	5/8/2007	3	Mold	MCT	Alt Reducing Fill Grout 2	070070
TNK035A3	5/8/2007	3	Mold	MCT	Alt Reducing Fill Grout 2	070070
TNK036A3	5/8/2007	3	Mold	MCT	Alt Reducing Fill Grout 2	070070
TNK037A3	5/8/2007	3	Mold	MCT	Alt Reducing Fill Grout 2	070070

[1]Mactec Engineering and Consulting, Inc.
[2]Geotesting Express, Inc.
[3]Idaho National Laboratory

Table 2. Design Mix for the Strong Grout (B2000-X-0-0-BS)[1].

Ingredients	Quantity/yd^3	Units
Portland Cement	550	lbs
Sand	2285	lbs
Water	65	gal
Kelco-Crete[2]	275	grams
Advaflow[3]	90	fl. oz.
WCMR (unitless ratio)	0.99	

[1]Internal mix ID = 070025.1 and 070025.2
[2]Kelco-Crete - plasticizer
[3]High Range Water Reducer

Table 3. Design Mix for the Reducing Fill Grout (OPDEXE-X-P-0-BS)[1].

Ingredients	Quantity/yd^3	Units
Portland Cement	75	lbs
Fly Ash	375	lbs
Slag	210	lbs
Sand	2300	lbs
Water	60	gal
Kelco-Crete[2]	275	grams
Advaflow[3]	90	fl. oz.
Sodium Thiosulfate[4]	2.1	Lbs
WCMR (unitless ratio)	0.76	

[1]Internal mix ID = 070027.1 and 070027.2
[2]Kelco-Crete - plasticizer
[3]High Range Water Reducer
[4]Sodium Thiosulfate – reducing agent

Table 4. Design Mix for Alternative Reducing Fill Grout 1A[1].

Ingredients	Quantity/yd^3	Units
Portland Cement	185	lbs
Fly Ash	580	lbs
Slag	260	lbs
Sand	1885	lbs
Water	60	gal
Kelco-Crete[2]	216	grams
Sika ViscoCrete 2100[3]	54	fl. oz.
Recover[4]	10	fl. oz.
Sodium Thiosulfate[5]	2.1	Lbs
WCMR (unitless ratio)	0.49	

[1]Internal mix ID = 070044
[2]Kelco-Crete - plasticizer
[3]Sika ViscoCrete 2100 – high range water reducing admixture
[4]Recover – hydration stabilizer
[5]Sodium Thiosulfate – reducing agent

Table 5. Design Mix for Alternative Reducing Fill Grout 1B[1].

Ingredients	Quantity/yd^3	Units
Portland Cement	300	lbs
Fly Ash	800	lbs
Slag	310	lbs
Sand	1420	lbs
Water	63	gal
Kelco-Crete[2]	216	grams
Sika ViscoCrete 2100[3]	54	fl. oz.
Recover[4]	10	fl. oz.
Sodium Thiosulfate[5]	2.1	Lbs
WCMR (unitless ratio)	0.37	

[1]Internal mix ID = 070043
[2]Kelco-Crete - plasticizer
[3]Sika ViscoCrete 2100 – high range water reducing admixture
[4]Recover – hydration stabilizer
[5]Sodium Thiosulfate – reducing agent

Table 6. Design Mix for Alternative Reducing Fill Grout 2[1].

Ingredients	Quantity/yd^3	Units
Portland Cement	185	lbs
Fly Ash	850	lbs
Slag	260	lbs
Sand	942	lbs
Aggregate (#8 stone)	946	lbs
Water	61.1	gal
Kelco-Crete[2]	216	grams
Advaflex[3]	54	fl. oz.
Recover[4]	4	fl. oz.
Sodium Thiosulfate[5]	2.1	Lbs
WCMR (unitless ratio)	0.39	

[1]Internal mix ID = 070070
[2]Kelco-Crete - plasticizer
[3]Advaflex – high range water reducing admixture
[4]Recover – hydration stabilizer
[5]Sodium Thiosulfate – reducing agent

Table 7. Methods of Analysis used for Tank Grout and Base Mat Surrogate Concrete Testing

Property	GTX Test Method	MCT Test Method	INL Test Method
Saturated Hydraulic Conductivity	ASTM D 5084, Method C	ASTM D 5084, Method B	ASTM D 6527
Unsaturated Hydraulic Conductivity	NA	NA	ASTM D 6527
Water Retention	ASTM D 2325	ASTM D 2325	Dane and Topp, 2002[a]
Dry Bulk Density	ASTM C 642 [b]	ASTM C 642 [b]	Dane and Topp, 2002
Porosity	ASTM C 642 [b]	ASTM C 642 [b]	Dane and Topp, 2002

[a]Methods of Soil Analysis, Part 4 – Physical Methods.
[b]Modified ASTM C 642: Dry Bulk Density is determined by dividing the dry weight of the sample by the total sample volume. Porosity is determined by dividing the volume of the saturated water filled pores by the total sample volume. The volume of the saturated water filled pores is determined by subtracting the dry weight of the sample from the saturated weight of the sample and dividing by the density of water (approximately 1 g/cm^3). The total sample volume is determined by measuring the physical dimensions of the sample.

Table 8. Preliminary Compressive Strength for the Strong Grout (B2000-X-0-0-BS)[1].

Days Aged	Date Tested	Batch 070025.1 Strength[2], (psig)	Batch 070025.2 Strength[3], (psig)
14	3/7/2007	1570	920
28	3/21/2007	1520	1060
62	4/24/2007	1980	1180
62	4/24/2007	2110	1160
90	5/22/2007	2070	1160
90	5/22/2007	2110	1170
180	8/20/2007	2110	1170
180	8/20/2007	2050	-

[1]See Ganguly and Langton (2007) for complete results and discussion of the strength data.
[2]Samples TNK023S and TNK024S were from Batch 070025.1
[3]Samples TNK001S, TNK002S, TNK003S, and TNK004S were from Batch 070025.2

Table 9. Preliminary Compressive Strength for the Reducing Fill Grout (OPDEXE-X-P-0-BS)[1].

Days Aged	Date Tested	Batch 070027.1 Strength, (psig)	Batch 070027.2 Strength, (psig)
14	3/8/2007	990	1000
28	3/22/2007	1760	1660
61	4/24/2007	2380	2140
61	4/24/2007	2270	2130
90	5/23/2007	2470	2200
90	5/23/2007	2300	2250
180	8/21/2007	2450	2390
180	8/21/2007	2410	-

[1]See Ganguly and Langton (2007) for complete results and discussion of the strength data.

Table 10. Preliminary Compressive Strength for Alternative Reducing Fill Grout 1A[1]

Days Aged	Date Tested	Batch 070044 Strength, (psig)
28	4/25/2007	3500
28	4/25/2007	3610
90	6/26/2007	5430
90	6/26/2007	5160

[1]See Ganguly and Langton (2007) for complete results and discussion of the strength data.

Table 11. Preliminary Compressive Strength for Alternative Reducing Fill Grout 1B[1].

Days Aged	Date Tested	Batch 070043 Strength, (psig)
14	4/4/2007	2420
28	4/18/2007	5080
28	4/18/2007	5230
90	6/19/2007	7360
90	6/19/2007	7570

[1]See Ganguly and Langton (2007) for complete results and discussion of the strength data.

Table 12. Preliminary Compressive Strength for Alternative Reducing Fill Grout 2[1].

Days Aged	Date Tested	Batch 070070 Strength, (psig)
28	6/5/2007	3490
28	6/5/2007	3380
90	8/6/2007	4600
90	8/6/2007	5080

[1]See Ganguly and Langton (2007) for complete results and discussion of the strength data.

Table 13. Hydraulic Properties of the Strong Grout (B2000-X-0-0-BS).

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4] (cm/s)
TNK001S[5]	MCT[6]	3" Mold	1.79	2.51	0.269	2.8E-08
TNK002S[5]	MCT	3" Mold	1.78	2.51	0.277	2.5E-08
TNK003S[5]	MCT	3" Mold	1.78	2.51	0.265	2.9E-08
TNK004S[5]	MCT	3" Mold	1.80	2.51	0.275	9.4E-09
TNK023S	MCT	3" Mold	1.81	2.51	0.268	6.8E-09
TNK024S	MCT	3" Mold	1.81	2.51	0.257	2.7E-08

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]These samples are from mix batch 070025.2 for which the compressive strength was approximately half that required by specifications (See Table 8).
[6]Mactec Engineering and Consulting, Inc.

Table 14. Hydraulic Properties of the Reducing Fill Grout (OPDEXE-X-P-0-BS).

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4] (cm/s)
TNK005R	MCT[5]	3" Mold	1.86	2.51	0.219	1.0E-08
TNK006R	MCT	3" Mold	1.81	2.51	0.275	8.5E-08
TNK007R	MCT	3" Mold	1.81	2.51	0.275	1.0E-08
TNK008R	MCT	3" Mold	1.80	2.51	0.271	5.2E-08
TNK025R	MCT	3" Mold	1.80	2.51	0.278	4.3E-08
TNK026R	MCT	3" Mold	1.81	2.51	0.277	1.7E-08

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]Mactec Engineering and Consulting, Inc.

Table 15. Hydraulic Properties of the Reducing Fill Grout (OPDEXE-X-P-0-BS) as Measured by INL.

Sample Id	Sample Type	Permeameter Saturated Hydraulic Conductivity[1] (cm/s)	UFA Centrifuge[2] RPM	UFA Centrifuge Hydraulic Conductivity (cm/s)	Dry Bulk Density (g/cm^3)
TNK019R-A	1" Core	<1.00E-08	2500	9.0E-11	-
TNK019R-B	1" Core	<1.00E-08	2500	4.0E-10	-
TNK019R-E[3]	1" Core	-	-	-	1.835
TNK019R-F[4]	1" Core	-	-	-	1.843
TNK020R-A	1" Core	<1.00E-08	2500	5.0E-10	
TNK020R-B	1" Core	<1.00E-08	2500	5.0E-10	
TNK020R-E[5]	1" Core	-	-	-	1.815
TNK020R-F[6]	1" Core	-	-	-	1.810

INL = Idaho National Laboratory
[1] The saturated hydraulic conductivity of the potted samples was estimated using a falling head method with 2 meters of head. Accurate determination of the saturated hydraulic conductivity on the 1 inch potted samples was not possible due to the low fluxes through the samples
[2] The UFA samples were run at 2500 rpm in the centrifuge for over 100 hours to reach steady-state conditions. The centrifuge falling head method was used. These results are considered to be representative of the actual saturated hydraulic conductivity of these very tight samples.
[3]Bulk density for TNK019R-E is the average of sub-cores TNK019R-1-5.
[4]Bulk density for TNK019R-F is the average of sub-cores TNK019R-6-10.
[5]Bulk density for TNK020R-E is the average of sub-cores TNK020R-1-5.
[6]Bulk density for TNK020R-F is the average of sub-cores TNK020R-6-10.

Table 16. Hydraulic Properties of Alternative Reducing Fill Grout 1A.

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4,5] (cm/s)
TNK027A1	GTX[6]	3" Mold	1.84	2.38	0.190	8.2E-09
TNK028A1	GTX	3" Mold	1.88	2.48	0.250	9.5E-09

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]It is likely that the saturated hydraulic conductivity of this material would be substantially lower with additional cure time beyond the 28 days of these samples due to the use of fly ash and blast furnace slag the formulation.
[6]Geotesting Express, Inc.

Table 17. Hydraulic Properties of Alternative Reducing Fill Grout 1B.

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4,5] (cm/s)
TNK029A2	GTX[6]	3" Mold	1.82	2.43	0.230	1.0E-08
TNK030A2	GTX	3" Mold	1.86	2.42	0.250	1.5E-08
TNK031A2	GTX	3" Mold	1.86	2.41	0.240	1.4E-08
TNK032A2	GTX	3" Mold	1.85	2.43	0.240	1.3E-08

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]It is likely that the saturated hydraulic conductivity of this material would be substantially lower with additional cure time beyond the 28 days of these samples due to the use of fly ash and blast furnace slag the formulation.
[6]Geotesting Express, Inc.

Table 18. Hydraulic Properties of Alternative Reducing Fill Grout 2.

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4,5] (cm/s)
TNK034A3	MCT[6]	3" Mold	2.06	2.51	0.186	6.3E-09
TNK035A3	MCT	3" Mold	1.94	2.51	0.214	5.5E-09
TNK036A3	MCT	3" Mold	1.92	2.51	0.225	6.6E-09
TNK037A3	MCT	3" Mold	1.94	2.51	0.211	8.1E-09

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]It is likely that the saturated hydraulic conductivity of this material would be substantially lower with additional cure time beyond the 28 days of these samples due to the use of fly ash and blast furnace slag the formulation.
[6]Mactec Engineering and Consulting, Inc.

Table 19. Hydraulic Properties of the Base Mat Surrogate Concrete.

Sample Id	Lab	Sample Type	Bulk Density[1] (g/cm^3)	Particle Density[2] (g/cm^3)	Water Exchangeable Porosity[3]	Permeameter Saturated Hydraulic Conductivity[4] (cm/s)
TNK009B	GTX[5]	3" Mold	2.14	2.54	0.150	1.6E-08
TNK010B	GTX	3" Mold	2.01	2.51	0.170	3.1E-08
TNK011B	GTX	3" Mold	2.05	2.53	0.190	6.0E-08
TNK012B	GTX	3" Mold	2.04	2.44	0.160	3.3E-08

[1]From saturated hydraulic conductivity samples.
[2]Particle density measured per ASTM D 854
[3]Water exchangeable porosity calculated as $n = ((M_{sat} - M_{dry})/\rho_w) / Vol$
[4]Effective confining stress = 10 psig.
[5]Geotesting Express, Inc.

Table 20. Summary Hydraulic Properties for Tank Grouts and Base Mat Surrogate Concrete.

	Bulk Density (g/cm³)			Particle Density (g/cm³)			Permeability (cm/sec)			Water Exchangeable Porosity (fraction)		
Description	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Strong Grout[1]	1.78	1.81	1.80	2.51	2.51	2.51	6.8E-09	2.9E-08	2.1E-08	0.257	0.277	0.269
Reducing Fill Grout	1.80	1.86	1.81	2.51	2.51	2.51	1.0E-08	8.5E-08	3.6E-08	0.219	0.278	0.266
Alt. Reducing Fill Grout 1A	1.84	1.88	1.86	2.38	2.44	2.41	8.2E-09	9.5E-09	8.9E-09	0.190	0.250	0.220
Alt. Reducing Fill Grout 1B	1.82	1.86	1.85	2.41	2.43	2.42	1.0E-08	1.5E-08	1.3E-08	0.230	0.250	0.240
Alt. Reducing Fill Grout 2	1.92	2.06	1.96	2.51	2.51	2.51	5.5E-09	8.1E-09	6.6E-09	0.186	0.225	0.209
Base Mat Surrogate	2.01	2.14	2.06	2.44	2.54	2.51	1.6E-08	6.0E-08	3.5E-08	0.150	0.190	0.168

[1]Summary results for the strong grout exclude samples TNK001S, TNK002S, TNK003S, and TNK004S which all came from batch 070025.2. These results were excluded because the compressive strength for this batch of grout did not meet the specified 28 day strength of 2000 psig.

Table 21. Water Retention Data for the Strong Grout (B2000-X-0-0-BS).

Sample Id[1]	Bulk Density (g/cm^3)	Potential (cm)				
		0	-510.35	-1,020.70	-5,103.50	-15,310.50
		(0.00 bars)	(-0.50 bars)	(-1.0 bars)	(-5.0 bars)	(-15.0 bars)
		Volumetric Water Content (cm^3/cm^3)				
TNK001S[2]	1.76	0.298	0.287	0.285	0.272	0.261
TNK002S[2]	1.73	0.304	0.292	0.289	0.279	0.270
TNK003S[2]	1.75	0.307	0.291	0.288	0.276	0.267
TNK004S[2]	1.76	0.302	0.293	0.292	0.280	0.272
TNK023S	1.77	0.289	0.281	0.264	0.257	0.246
TNK024S	1.74	0.278	0.266	0.265	0.262	0.254

[1]Samples tested by Mactec Engineering and Consulting, Inc. (MCT).
[2]These samples are from mix batch 070025.2 for which the compressive strength was approximately half that required by specifications

Table 22. Water Retention Data for the Reducing Fill Grout (OPDEXE-X-P-0-BS).

Sample Id[1]	Bulk Density (g/cm^3)	Potential (cm)				
		0	-510.35	-1,020.70	-5,103.50	-15,310.50
		(0.00 bars)	(-0.50 bars)	(-1.0 bars)	(-5.0 bars)	(-15.0 bars)
		Volumetric Water Content (cm^3/cm^3)				
TNK005R	1.77	0.283	0.272	0.264	0.257	0.249
TNK006R	1.76	0.318	0.305	0.301	0.293	0.286
TNK007R	1.81	0.273	0.264	0.262	0.254	0.252
TNK008R	1.81	0.280	0.268	0.261	0.245	0.245
TNK025R	1.82	0.289	0.278	0.277	0.272	0.265
TNK026R	1.76	0.297	0.287	0.284	0.278	0.274

[1]Samples tested by Mactec Engineering and Consulting, Inc. (MCT).

Table 23. Water Retention Properties of the Reducing Fill Grout (mix OPDEXE-X-P-0-BS) as measured by INL.

		Sample ID					
			TNK019R-C[1]	TNK019R-D[2]		TNK020R-C[3]	TNK020R-D[4]
Method	**Sample Description**	**Potential (cm)**	**Volumetric Water Content (cm^3/cm^3)**	**Volumetric Water Content (cm^3/cm^3)**	**Potential (cm)**	**Volumetric Water Content (cm^3/cm^3)**	**Volumetric Water Content (cm^3/cm^3)**
Vacuum Saturation[5]	~1" diameter by ~0.8 cm length	0.00E+00	0.264	0.267	0.00E+00	0.272	0.268
Hanging Column	~1" diameter by ~0.8 cm length	6.12E+01	0.261	0.263	6.12E+01	0.270	0.268
Hanging Column	~1" diameter by ~0.8 cm length	1.33E+02	0.261	0.263	1.33E+02	0.268	0.265
Pressure Plate	~1" diameter by ~0.8 cm length	7.95E+02	0.244	0.247	7.95E+02	0.258	0.253
Pressure Plate	~1" diameter by ~0.8 cm length	3.57E+03	0.238	0.241	3.57E+03	0.253	0.249
Pressure Plate	~1" diameter by ~0.8 cm length	1.27E+04	0.233	0.238	1.27E+04	0.248	0.244
Chilled Mirror[6]	~3 mm diameter grains	4.56E+04	0.225	0.225	3.54E+04	0.242	0.242

[1]Volumetric water contents for TNK019R-C are the average of sub-cores TNK019R-1, 2, 6, & 7.
[2]Volumetric water contents for TNK019R-D are the average of sub-cores TNK019R-3, 4, 8, & 9.
[3]Volumetric water contents for TNK020R-C are the average of sub-cores TNK020R-1, 2, 6, & 7.
[4]Volumetric water contents for TNK020R-D are the average of sub-cores TNK020R-3, 4, 8, & 9.
[5]Vacuum Saturation is considered to be the water exchangeable porosity.
[6]Chilled mirror measurements for TNK019R and TNK020R were averaged from sub-cores TNK019R-6&7 and TNK020R-6&7, respectively.

Table 24. Water Retention Data for Alternative Reducing Fill Grout 1A.

Sample Id[1]	Location[2]	Bulk Density (g/cm^3)	Potential (cm)					
			0	-102.07	-510.35	-1,020.70	-5,103.50	-15,310.50
			(0.00 bars)	(-0.10 bars)	(-0.50 bars)	(-1.0 bars)	(-5.0 bars)	(-15.0 bars)
			Volumetric Water Content (cm^3/cm^3)					
TNK027A1	Top	1.84	0.184	0.170	0.158	0.145	0.130	0.124
	Bottom	1.92	0.211	0.195	0.177	0.162	0.153	0.141
TNK028A1	Top	1.84	0.250	0.241	0.226	0.207	0.190	0.171
	Bottom	1.80	0.243	0.229	0.213	0.195	0.175	0.164

[1]Samples tested by Geotesting Express, Inc. (GTX).
[2]GTX tested wafers from the top and bottom of each mold sample.

Table 25. Water Retention Data for Alternative Reducing Fill Grout 1B.

Sample Id[1]	Location[2]	Bulk Density (g/cm^3)	Potential (cm)					
			0	-102.07	-510.35	-1,020.70	-5,103.50	- 15,310.50
			(0.00 bars)	(-0.10 bars)	(-0.50 bars)	(-1.0 bars)	(-5.0 bars)	(-15.0 bars)
			Volumetric Water Content (cm^3/cm^3)					
TNK029A2	Top	1.86	0.261	0.244	0.225	0.212	0.204	0.194
	Bottom	1.86	0.258	0.239	0.207	0.194	0.185	0.177
TNK030A2	Top	2.01	0.273	0.254	0.238	0.221	0.212	0.199
	Bottom	1.94	0.270	0.246	0.232	0.217	0.204	0.193
TNK031A2	Top	1.77	0.248	0.241	0.226	0.211	0.198	0.194
	Bottom	1.82	0.255	0.239	0.228	0.211	0.199	0.192
TNK032A2	Top	1.69	0.227	0.212	0.196	0.185	0.170	0.165
	Bottom	1.68	0.227	0.201	0.183	0.170	0.158	0.153

[1]Samples tested by Geotesting Express, Inc. (GTX).
[2]GTX tested wafers from the top and bottom of each mold sample.

Table 26. Water Retention Data for Alternative Reducing Fill Grout 2.

Sample Id[1]	Bulk Density (g/cm^3)	Potential (cm)				
		0 (0.00 bars)	-510.35 (-0.50 bars)	-1,020.70 (-1.0 bars)	-5,103.50 (-5.0 bars)	-15,310.50 (-15.0 bars)
		Volumetric Water Content (cm^3/cm^3)				
TNK034A3	1.96	0.216	0.203	0.201	0.192	0.190
TNK035A3	2.01	0.191	0.178	0.177	0.170	0.168
TNK036A3	1.98	0.196	0.184	0.182	0.176	0.174
TNK037A3	2.04	0.181	0.168	0.166	0.162	0.160

[1]Samples tested by Mactec Engineering and Consulting, Inc. (MCT).

Table 27. Water Retention Data for the Base Mat Surrogate Concrete.

Sample Id[1]	Location[2]	Bulk Density (g/cm^3)	Potential (cm)					
			0 (0.00 bars)	-102.07 (-0.10 bars)	-510.35 (-0.50 bars)	-1,020.70 (-1.0 bars)	-5,103.50 (-5.0 bars)	-15,310.50 (-15.0 bars)
			Volumetric Water Content (cm^3/cm^3)					
TNK009B	Top	1.93	0.144	0.129	0.106	0.099	0.076	0.060
	Bottom	2.01	0.150	0.142	0.105	0.100	0.081	0.068
TNK010B	Top	1.98	0.146	0.130	0.114	0.095	0.084	0.072
	Bottom	2.03	0.152	0.133	0.119	0.096	0.080	0.065
TNK011B	Top	1.91	0.139	0.124	0.106	0.083	0.074	0.066
	Bottom	1.88	0.141	0.127	0.108	0.088	0.076	0.066
TNK012B	Top	1.98	0.145	0.126	0.114	0.102	0.088	0.079
	Bottom	1.99	0.148	0.128	0.113	0.099	0.082	0.077

[1]Samples tested by Geotesting Express, Inc. (GTX).
[2]GTX tested wafers from the top and bottom of each mold sample.

Table 28. Van Genuchten Transport Parameters[1].

Mix	Location	θ_s (cm^3/cm^{-3})	θ_r (cm^3/cm^{-3})	α (1/cm)	n	m	r^2
Strong Grout[2]	-	0.296	0.234	0.0060	1.1529	0.1326	0.999
Reducing Fill Grout[2]	-	0.290	0.245	0.006	1.202	0.1677	0.999
Reducing Fill Grout[3]		0.266	0.215	0.00733	1.2290	0.1863	-
Reducing Fill Grout[4]		0.270	0.233	0.0104	1.2290	0.1863	-
Alt. Reducing Fill Grout 1A	Top	0.217	0.078	0.0085	1.1414	0.1239	0.993
Alt. Reducing Fill Grout 1A	Bottom	0.227	0.109	0.0114	1.1926	0.1615	0.994
Alt. Reducing Fill Grout 1B	Top	0.252	0.167	0.0120	1.2677	0.2112	0.994
Alt. Reducing Fill Grout 1B	Bottom	0.253	0.157	0.0182	1.2635	0.2085	0.995
Alt. Reducing Fill Grout 2	-	0.196	0.162	0.0160	1.2081	0.1722	0.997
Base Mat Surrogate	Top	0.144	0.023	0.0137	1.1772	0.1505	0.995
Base Mat Surrogate	Bottom	0.148	0.040	0.0101	1.2573	0.2047	0.997

[1]Data analyzed using Mualem relationship between n and m where m = 1 – 1/n.
[2]Additional water retention data is anticipated from MCT which will be evaluated versus the recommended transport parameters for both the strong grout and the reducing fill grout.
[3]Analysis by INL on sample TNK019R.
[4]Analysis by INL on sample TNK020R.

Table 29. Recommended Hydraulic Property Values.

Description	Permeability (cm/sec)	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Water Exchangeable Porosity (fraction)
Strong Grout	2.1E-08	1.80	2.51	0.269
Reducing Fill Grout	3.6E-08	1.81	2.51	0.266
Alt. Reducing Fill Grout 1A	8.9E-09	1.86	2.41	0.220
Alt. Reducing Fill Grout 1B	1.3E-08	1.85	2.42	0.240
Alt. Reducing Fill Grout 2	6.6E-09	1.96	2.51	0.209
Base Mat Surrogate	3.5E-08	2.06	2.51	0.168

Table 30. Recommended van Genuchten Transport Parameters[1].

Mix	θ_s (cm^3/cm^{-3})	θ_r (cm^3/cm^{-3})	α (1/cm)	n	m
Strong Grout[2]	0.296	0.234	0.0060	1.1529	0.1326
Reducing Fill Grout[2]	0.279	0.234	0.008	1.2153	0.1770
Alternative Fill Grout 1A	0.222	0.093	0.010	1.1670	0.1427
Alternative Fill Grout 1B	0.252	0.162	0.015	1.2656	0.2099
Alternative Fill Grout 2	0.196	0.162	0.016	1.2081	0.1722
Base Mat Surrogate	0.146	0.031	0.012	1.2173	0.1776

[1]A tabulation of the recommended characteristic curves, produced from these recommended parameters, is provided in Appendix D.

[2]Additional water retention data is anticipated from MCT which will be evaluated versus the recommended transport parameters for both the strong grout and the reducing fill grout.

APPENDIX A. MACTEC AND GTX DATA SHEETS ON CONCRETE/GROUT TESTING

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/7/2007*
Boring No.	*TNK001S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7367*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*15.0*
Wet Unit Weight, pcf:	*128.6*
Dry Unit Weight, pcf:	*111.8*
Porosity Based on SG	*0.287*
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	*0.269*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***2.8E-08***

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/7/2007*
Boring No.	*TNK002S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7368*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*15.6*
Wet Unit Weight, pcf:	*128.2*
Dry Unit Weight, pcf:	*110.9*
Porosity Based on SG	*0.293*
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	*0.277*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***2.5E-08***

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/7/2007*
Boring No.	*TNK003S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7369*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*14.9*
Wet Unit Weight, pcf:	*127.8*
Dry Unit Weight, pcf:	*111.3*
Porosity Based on SG	*0.290*
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	*0.265*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***2.9E-08***

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK004S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7370*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.3
Wet Unit Weight, pcf:	129.6
Dry Unit Weight, pcf:	112.4
Porosity Based on SG	0.283
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	0.275
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**9.4E-09**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK005R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7371*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	11.8
Wet Unit Weight, pcf:	129.8
Dry Unit Weight, pcf:	116.1
Porosity Based on SG	0.259
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.219
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**1.0E-08**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK005R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7371.4*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	11.8
Wet Unit Weight, pcf:	129.8
Dry Unit Weight, pcf:	116.1
Porosity Based on SG	0.259
Porosity $\{(M_{sat}-M_{dry})/p_w)/\text{Vol.}\}$	0.219
Effective Confining Pressure, psi	40.0
Hydraulic Conductivity, cm/sec. @20 °C	**3.7E-08**

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK006R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7372*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.3
Wet Unit Weight, pcf:	129.8
Dry Unit Weight, pcf:	112.6
Porosity Based on SG	0.282
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/\mathrm{Vol.}\}$	0.275
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**8.5E-08**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK006R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7372.4*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.3
Wet Unit Weight, pcf:	129.8
Dry Unit Weight, pcf:	112.6
Porosity Based on SG	0.282
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.275
Effective Confining Pressure, psi	40.0
Hydraulic Conductivity, cm/sec. @20 °C	***6.7E-08***

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK007R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7373*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.2
Wet Unit Weight, pcf:	130.2
Dry Unit Weight, pcf:	113.1
Porosity Based on SG	0.279
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.275
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**1.0E-08**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK007R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7373.4*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.2
Wet Unit Weight, pcf:	130.2
Dry Unit Weight, pcf:	113.1
Porosity Based on SG	0.279
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.275
Effective Confining Pressure, psi	40.0
Hydraulic Conductivity, cm/sec. @20 °C	**6.0E-08**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/11/2007*
Boring No.	*TNK008R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7374*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.1
Wet Unit Weight, pcf:	129.2
Dry Unit Weight, pcf:	112.3
Porosity Based on SG	0.283
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.271
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	5.2E-08

Remarks: Contract No. AC33159N
Task No. 13

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/20/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-09B*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21269*
Sample Description	*Concrete Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*2.7*
Wet Unit Weight, pcf:	*137.3*
Dry Unit Weight, pcf:	*133.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.6E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
express

HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/20/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-10B*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21270*
Sample Description	*Concrete Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*3.5*
Wet Unit Weight, pcf:	*130.0*
Dry Unit Weight, pcf:	*125.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.1E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/20/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-11B*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21271*
Sample Description	*Concrete Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*3.9*
Wet Unit Weight, pcf:	*132.3*
Dry Unit Weight, pcf:	*127.3*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***6.0E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
express

HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/20/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-12B*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21272*
Sample Description	*Concrete Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*3.9*
Wet Unit Weight, pcf:	*132.3*
Dry Unit Weight, pcf:	*127.3*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.3E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/25/2007*
Boring No.	*TNK23S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7641*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	14.8
Wet Unit Weight, pcf:	129.5
Dry Unit Weight, pcf:	112.8
Porosity Based on SG	0.280
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.268
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**6.8E-09**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/25/2007*
Boring No.	*TNK24S*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7642*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	14.2
Wet Unit Weight, pcf:	128.9
Dry Unit Weight, pcf:	112.8
Porosity Based on SG	0.280
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	0.257
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**2.7E-08**

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/25/2007*
Boring No.	*TNK25R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7643*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*15.5*
Wet Unit Weight, pcf:	*129.3*
Dry Unit Weight, pcf:	*112.0*
Porosity Based on SG	*0.286*
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	*0.278*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***4.3E-08***

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*5/25/2007*
Boring No.	*TNK26R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*6/7/2007*
Sample Depth	*N/A*	Lab No.	*7644*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*15.3*
Wet Unit Weight, pcf:	*129.9*
Dry Unit Weight, pcf:	*112.7*
Porosity Based on SG	*0.281*
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	*0.277*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***1.7E-08***

Remarks: Contract No. AC33159N
Task No. 13

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-06-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*7/24/2007*
Boring No.	*TNK26R*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*8/3/2007*
Sample Depth	*N/A*	Lab No.	*7644.4*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	15.3
Wet Unit Weight, pcf:	129.9
Dry Unit Weight, pcf:	112.7
Porosity Based on SG	0.281
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.277
Effective Confining Pressure, psi	40.0
Hydraulic Conductivity, cm/sec. @20 °C	**1.9E-08**

Remarks: Contract No. AC33159N
Task No. 14

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/25/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-027A1*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21277*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*10.0*
Wet Unit Weight, pcf:	*126.4*
Dry Unit Weight, pcf:	*114.9*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***8.2E-09***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/25/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-028A1*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21278*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*8.3*
Wet Unit Weight, pcf:	*126.7*
Dry Unit Weight, pcf:	*117.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***9.5E-09***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/20/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-029A2*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21273*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*13.3*
Wet Unit Weight, pcf:	*128.8*
Dry Unit Weight, pcf:	*113.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.0E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/25/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-030A2*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21274*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*8.9*
Wet Unit Weight, pcf:	*126.3*
Dry Unit Weight, pcf:	*116.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.5E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/25/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-031A2*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21275*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*9.9*
Wet Unit Weight, pcf:	*127.5*
Dry Unit Weight, pcf:	*116.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.4E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

GeoTesting
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HYDRAULIC CONDUCTIVITY

Project No.	*GTX-G1238*	Tested By	*MCM*
Project Name	*Tank Closure Grout Testing*	Test Date	*5/25/2007*
Boring No.	*N/A*	Reviewed By	*TAT*
Sample No.	*TNK-032A2*	Review Date	*5/31/2007*
Sample Depth		Lab No.	*21276*
Sample Description	*Grout Core*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*10.0*
Wet Unit Weight, pcf:	*127.1*
Dry Unit Weight, pcf:	*115.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.3E-08***

Remarks: WSRC Task 27
Contract No. AB80188N

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-03-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*7/9/2007*
Boring No.	*TNK034A3*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*7/16/2007*
Sample Depth	*N/A*	Lab No.	*7838*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	Core
Initial Water Content, %:	9.0
Wet Unit Weight, pcf:	139.9
Dry Unit Weight, pcf:	128.3
Porosity Based on SG	0.181
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	0.186
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**6.3E-09**

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-03-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*7/9/2007*
Boring No.	*TNK035A3*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*7/16/2007*
Sample Depth	*N/A*	Lab No.	*7839*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*11.0*
Wet Unit Weight, pcf:	*134.2*
Dry Unit Weight, pcf:	*120.9*
Porosity Based on SG	*0.229*
Porosity $((M_{sat}-M_{dry})/\rho_w)/Vol.)$	*0.214*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***5.5E-09***

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-03-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*7/9/2007*
Boring No.	*TNK036A3*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*7/16/2007*
Sample Depth	*N/A*	Lab No.	*7840*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

Sample Type:	*Core*
Initial Water Content, %:	*11.7*
Wet Unit Weight, pcf:	*134.1*
Dry Unit Weight, pcf:	*120.0*
Porosity Based on SG	*0.234*
Porosity $\{(M_{sat}-M_{dry})/p_w)/Vol.\}$	*0.225*
Effective Confining Pressure, psi	*10.0*
Hydraulic Conductivity, cm/sec. @20 °C	***6.6E-09***

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6141-03-0170*	Tested By	*HJ*
Project Name	*Hydraulic & Geotechnical Grout*	Test Date	*7/9/2007*
Boring No.	*TNK037A3*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*7/16/2007*
Sample Depth	*N/A*	Lab No.	*7841*
Sample Description	*Grout sample*		

ASTM D5084 - Falling Head

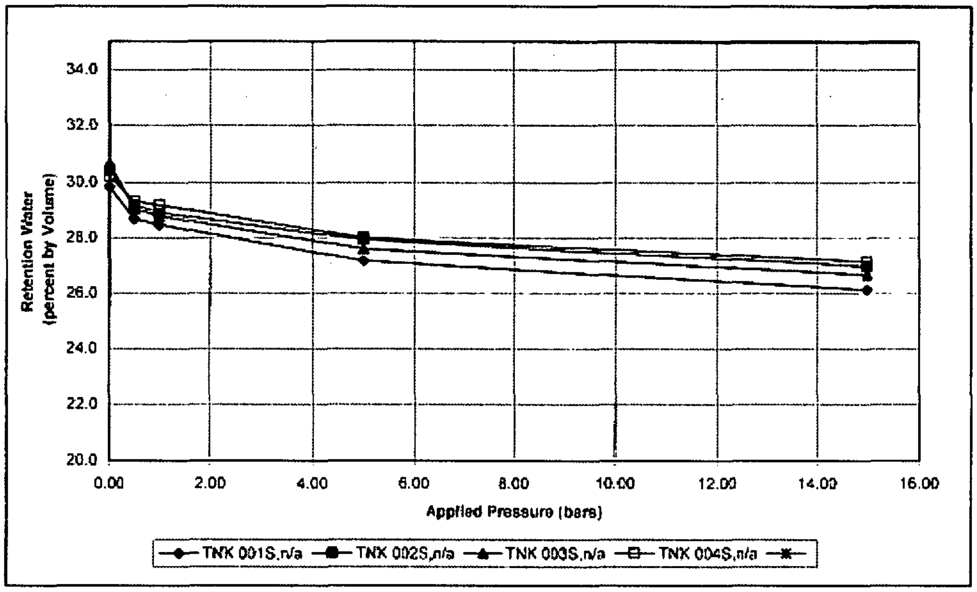
Sample Type:	Core
Initial Water Content, %:	10.9
Wet Unit Weight, pcf:	134.1
Dry Unit Weight, pcf:	121.0
Porosity Based on SG	0.228
Porosity $\{(M_{sat}-M_{dry})/\rho_w)/Vol.\}$	0.211
Effective Confining Pressure, psi	10.0
Hydraulic Conductivity, cm/sec. @20 °C	**8.1E-09**

Remarks: Contract No. AC33159N
Task No. 14

MACTEC

Water Retention Test
(ASTM D2325)

Project No	6141-03-0170	Project Name	Hydraulic & Geotechnical Grout Testing
Tested By	HJ	Test Date	9/14/07
Reviewed By	JL	Review Date	



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.50	1.0	5.0	15.0					
			Retained Water (percent by volume)									
TNK 001S,n/a	29.8	109.8	29.8	28.7	28.5	27.2	26.1					
TNK 002S,n/a	30.4	108.1	30.4	29.2	28.9	27.9	27.0					
TNK 003S,n/a	30.7	108.9	30.7	29.1	28.8	27.6	26.7					
TNK 004S,n/a	30.2	109.8	30.2	29.3	29.2	28.0	27.2					

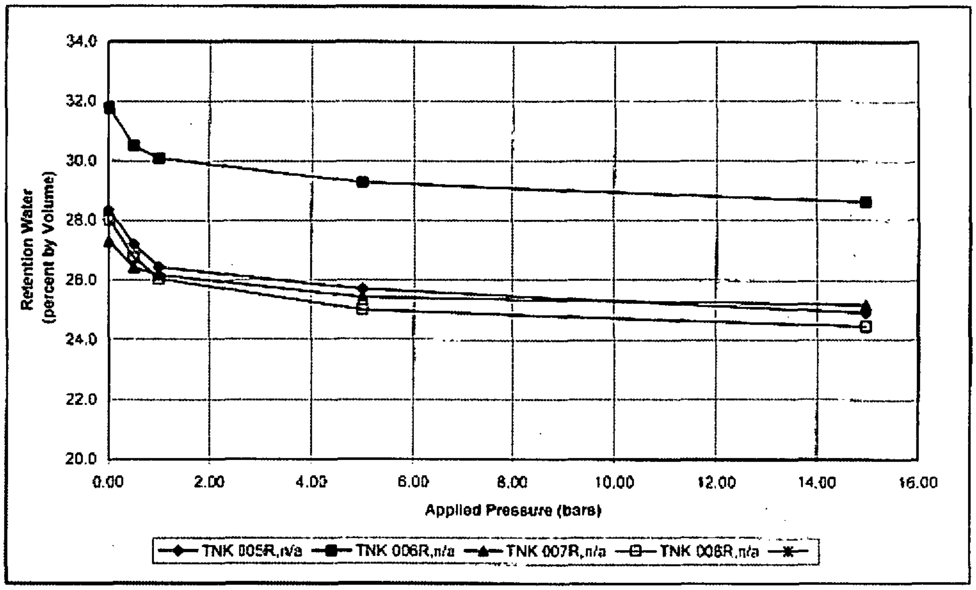
Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water. When testing at pressures higher than one bar, ASTM D2325 using similar equipment designed for the required capacity.

Contract no. AC33159N
Task no. 13

MACTEC

Water Retention Test
(ASTM D2325)

Project No	6141-03-0170	Project Name	Hydraulic & Geotechnical Grout Testing
Tested By	HJ	Test Date	9/28/07
Reviewed By	JW	Review Date	



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.50	1.0	5.0	15.0					
			Retained Water (percent by volume)									
TNK 005R,n/a	28.3	110.3	28.3	27.2	26.4	25.7	24.9					
TNK 006R,n/a	31.8	110.0	31.8	30.5	30.1	29.3	28.6					
TNK 007R,n/a	27.3	113.0	27.3	26.4	26.2	25.4	25.2					
TNK 008R,n/a	28.0	112.8	28.0	26.8	26.1	25.0	24.5					

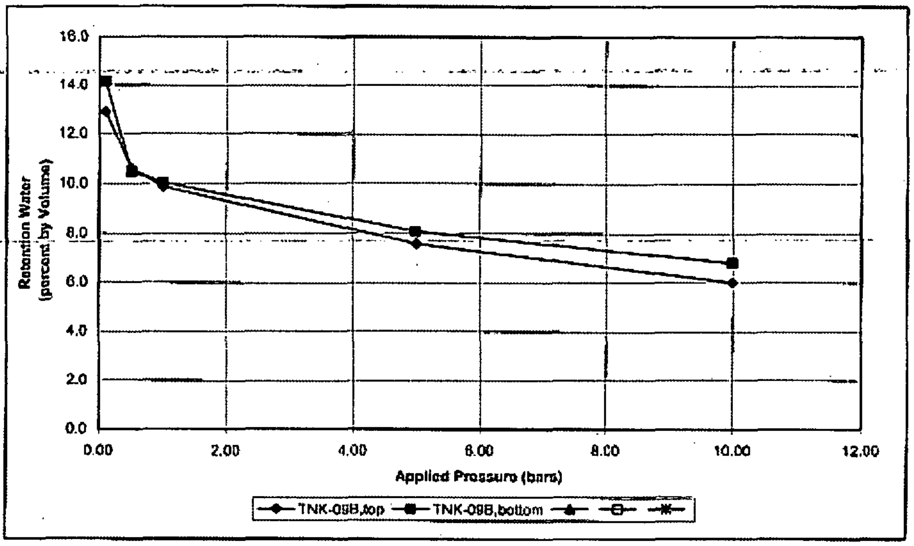
Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water. When testing at pressures higher than one bar, ASTM D2325 using similar equipment designed for the required capacity.

Contract no. AC33159N
Task no. 13

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



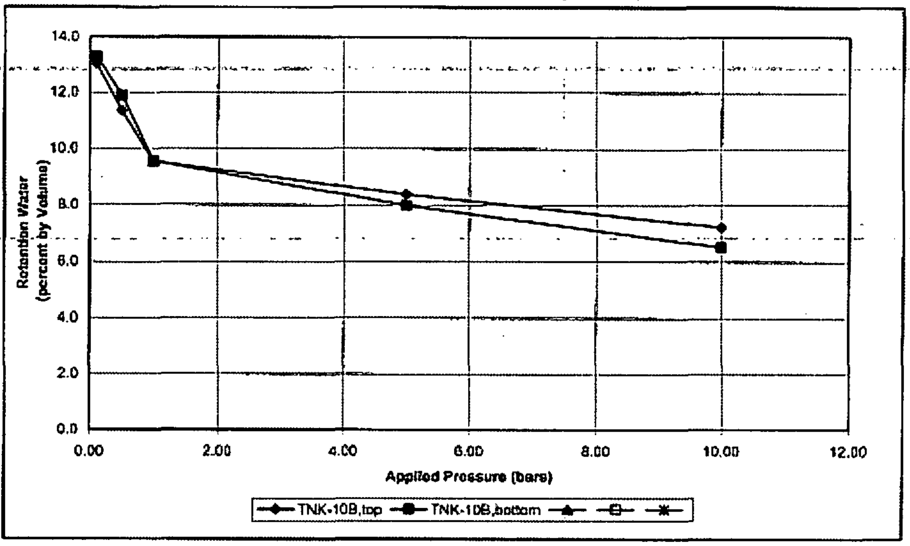
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-09B,top	14.4	120.2	12.9	10.6	9.9	7.6	6.0					
TNK-09B,bottom	15.0	125.2	14.2	10.5	10.0	8.1	6.8					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0				
			Retained Water (percent by volume)								
TNK-10B,top	14.6	123.6	13.0	11.4	9.5	8.4	7.2				
TNK-10B,bottom	15.2	126.4	13.3	11.9	9.6	8.0	6.5				

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting
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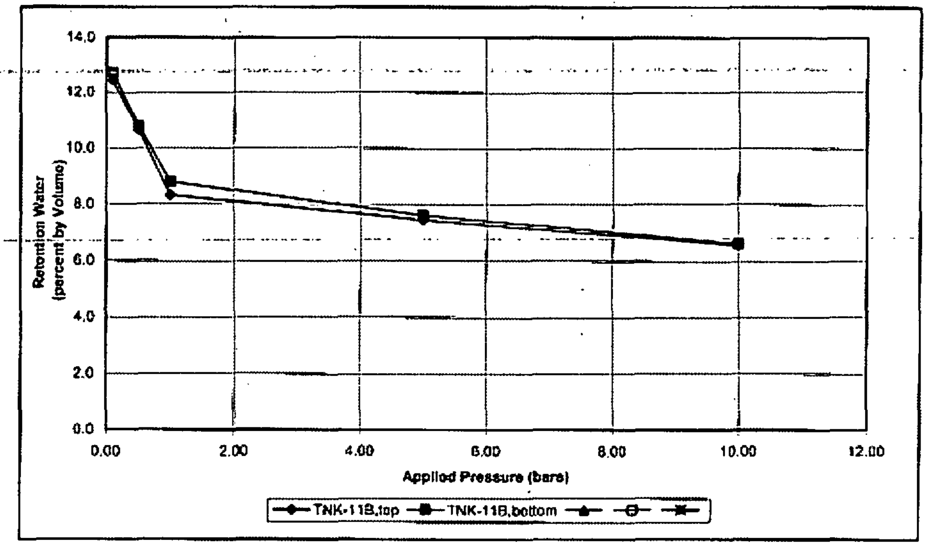
Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars)									
			0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-11B,top	13.9	119.0	12.4	10.6	8.3	7.4	6.6					
TNK-11B,bottom	14.1	117.2	12.7	10.8	8.8	7.6	6.6					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D853, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

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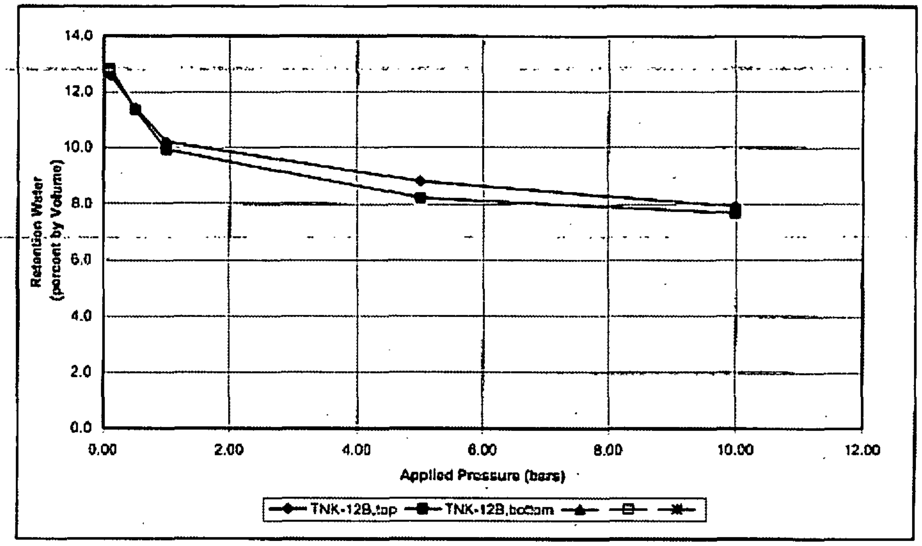
Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



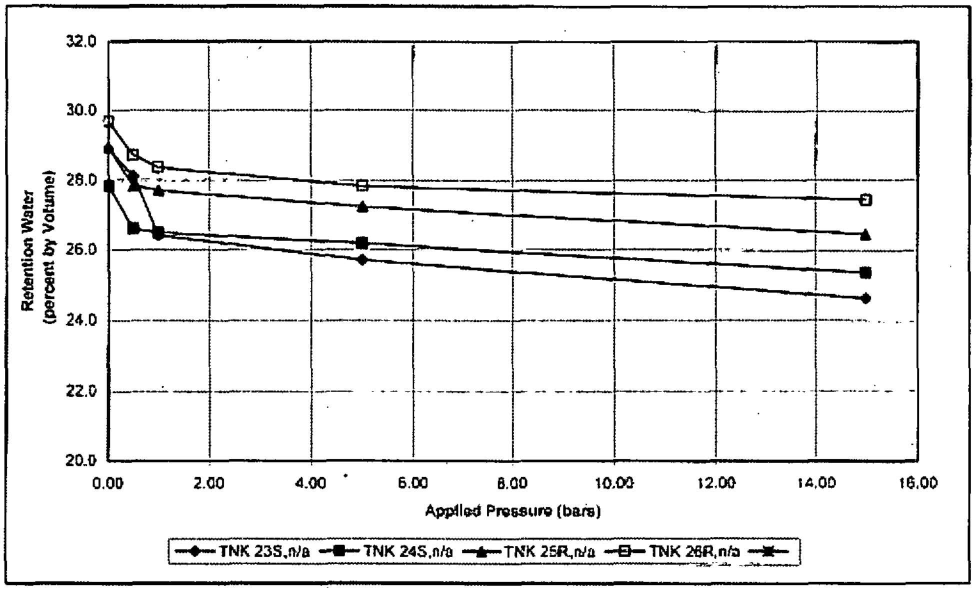
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-12B,top	14.5	123.2	12.6	11.4	10.2	8.8	7.9					
TNK-12B,bottom	14.8	124.1	12.8	11.3	9.9	8.2	7.7					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

MACTEC

Water Retention Test
(ASTM D2325)

Project No	6141-03-0170	Project Name	Hydraulic & Geotechnical Grout Testing
Tested By	HJ	Test Date	9/28/07
Reviewed By	JW	Review Date	



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.50	1.0	5.0	15.0					
			Retained Water (percent by volume)									
TNK 23S,n/a	28.9	110.7	28.9	28.1	26.4	25.7	24.6					
TNK 24S,n/a	27.8	108.4	27.8	26.6	26.5	26.2	25.4					
TNK 25R,n/a	28.9	113.3	28.9	27.8	27.7	27.2	26.5					
TNK 26R,n/a	29.7	109.6	29.7	28.7	28.4	27.8	27.4					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water. When testing at pressures higher than one bar, ASTM D2325 using similar equipment designed for the required capacity.

Contract no. AC33159N
Task no. 13

GeoTesting
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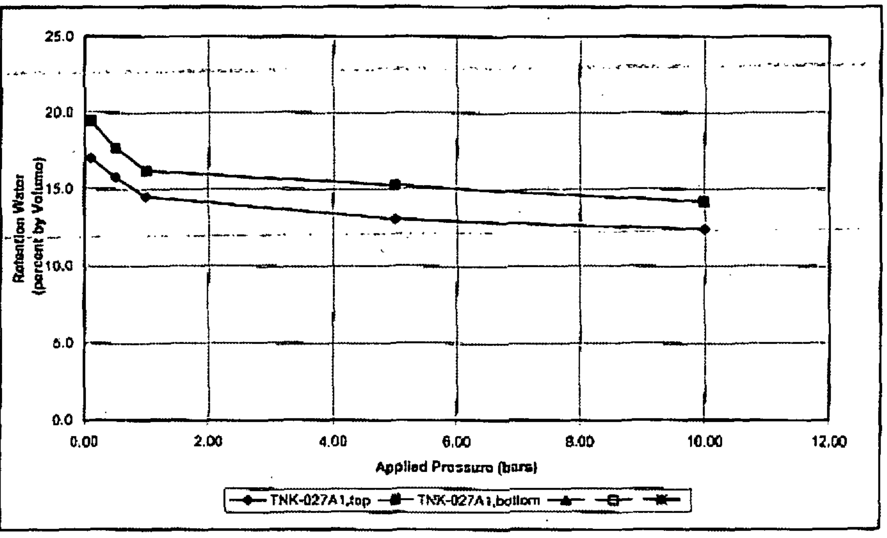
Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-027A1,top	18.4	114.7	17.0	15.8	14.5	13.0	12.4					
TNK-027A1,bottom	21.1	119.7	19.5	17.7	16.2	15.3	14.1					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

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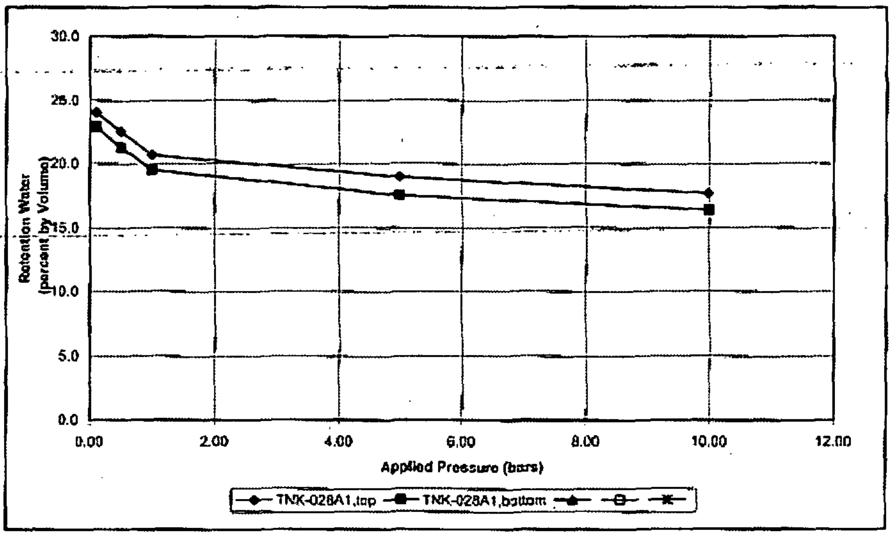
Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



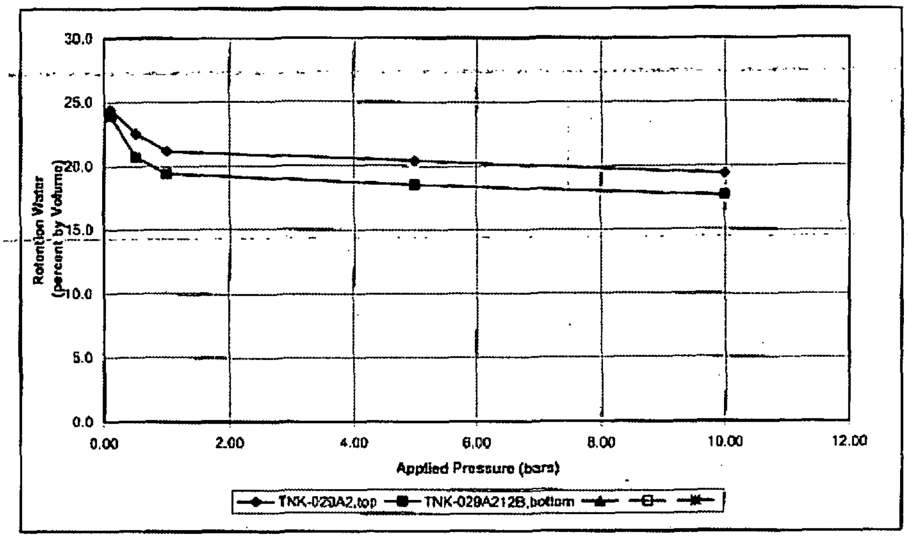
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars)									
			0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-028A1,top	25.0	115.0	24.1	22.6	20.7	19.0	17.7					
TNK-028A1,bottom	24.3	112.5	22.9	21.3	19.5	17.5	16.4					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



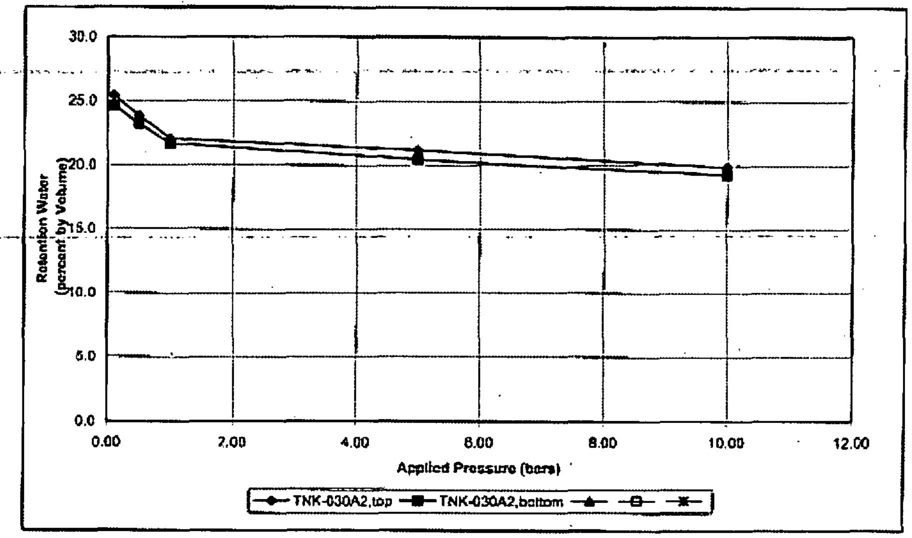
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-029A2,top	26.1	116.2	24.4	22.5	21.2	20.4	19.4					
TNK-029A212B,bottom	25.8	116.1	23.9	20.7	19.4	18.5	17.7					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



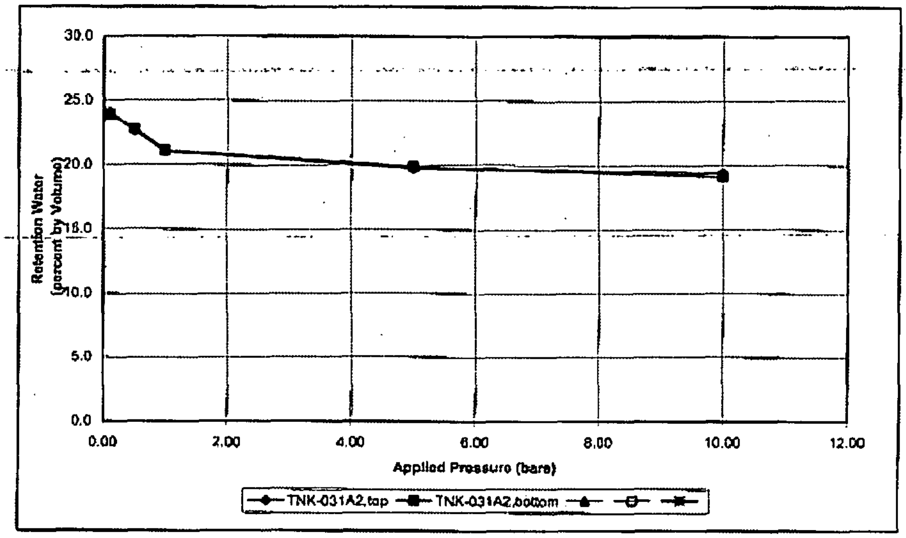
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars)									
			0.10	0.50	1.0	5.0	10.0					
			Retained Water (percent by volume)									
TNK-030A2.top	27.3	125.3	25.4	23.8	22.1	21.2	19.9					
TNK-030A2.bottom	27.0	121.0	24.6	23.2	21.7	20.4	19.3					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



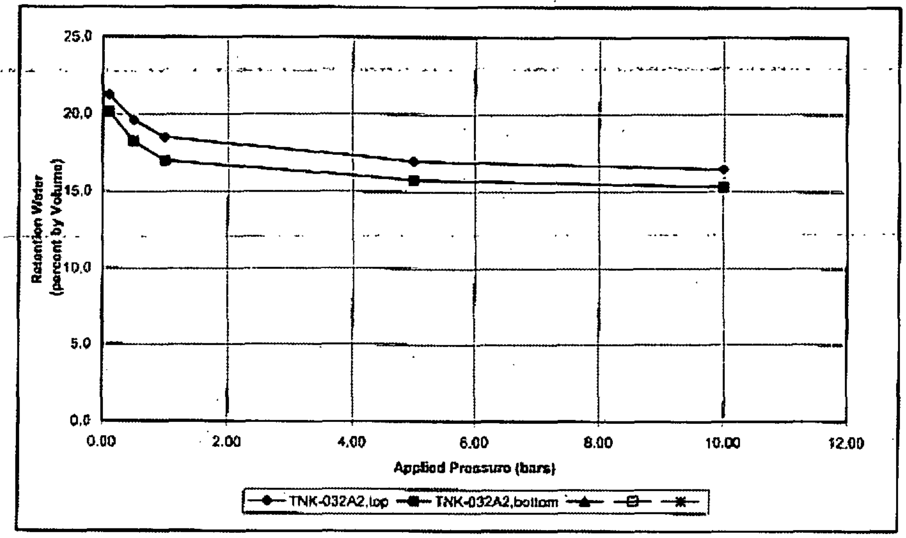
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0
			Retained Water (percent by volume)				
TNK-031A2,top	24.8	110.5	24.1	22.6	21.1	19.8	19.4
TNK-031A2,bottom	25.5	113.5	23.9	22.8	21.1	19.9	19.2

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

GeoTesting express

Water Retention Test
(ASTM D3152)

Project No	GTX-1238	Project Name	Tank Closure Grout Testing Project
Tested By	MM	Test Date	5/22/07
Reviewed By	TT	Review Date	5/30/07



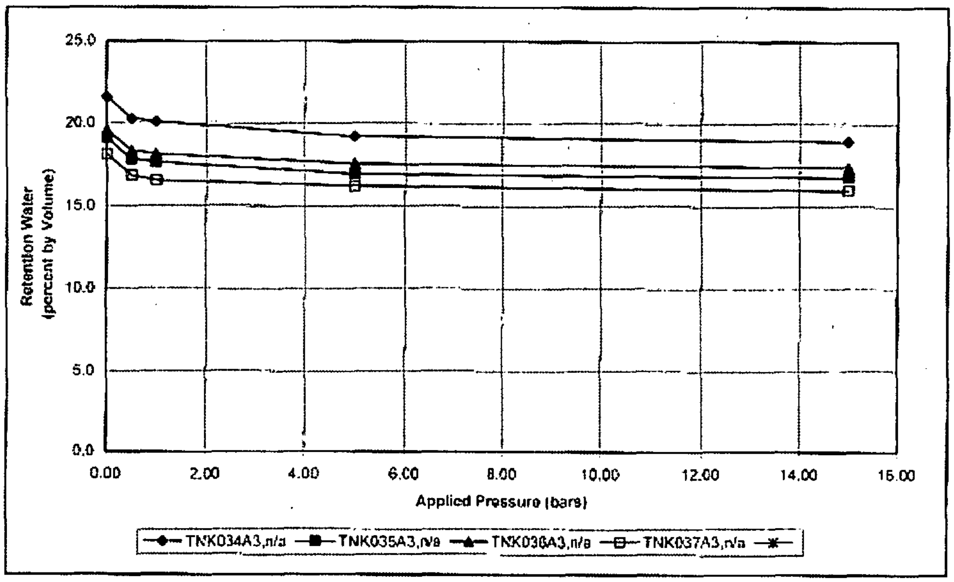
Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.10	0.50	1.0	5.0	10.0				
			Retained Water (percent by volume)								
TNK-032A2,top	22.7	105.1	21.2	19.6	18.6	17.0	16.5				
TNK-032A2,bottom	22.7	104.8	20.1	18.3	17.0	15.8	15.3				

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.

MACTEC

Water Retention Test
(ASTM D2325)

Project No	6141-03-0170	Project Name	Hydraulic & Geotechnical Grout Testing
Tested By	HJ	Test Date	710/07
Reviewed By	JW	Review Date	7/16/07



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.50	1.0	5.0	15.0					
			Retained Water (percent by volume)									
TNK034A3,n/a	21.6	122.4	21.6	20.3	20.1	19.2	19.0					
TNK035A3,n/a	19.1	125.4	19.1	17.8	17.7	17.0	16.8					
TNK036A3,n/a	19.6	123.8	19.6	18.4	18.2	17.6	17.4					
TNK037A3,n/a	18.1	127.5	18.1	16.8	16.6	16.2	16.0					

Remarks: The effective porosity (effective drainage porosity as defined by ASTM D653, as a percent, is found for an applied pressure by subtracting the retained percent water (by volume) from the saturation percent water.
When testing at pressures higher than one bar, ASTM D2325 using similar equipment designed for the required capacity.

Contract no. AC33159N
Task no. 14

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No.:	21269	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-09B
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.297			Tare No.	SGL-4E	
2	3.315	Top	2.787	Tare Weight	9.65	*grams*
3	3.31	Bottom	2.815	Wet Weight + Tare	732.56	*grams*
Average	3.31	Average	2.801	Dry Weight + Tare	722.64	*grams*
				Moisture Content	1.4	%

Total Weight of Soil + Tube Section	722.64	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.59	*lbs*
Volume of Sample	0.012	ft^3

RESULT SUMMARY

Moisture Content	1.4	%
Wet Density	135.1	*pcf*
Dry Density	133.2	*pcf*
Specific Gravity	2.54	
Porosity$^{(1)}$	0.16	
Porosity$^{(2)}$	0.15	

Remarks: Task Order # 27

Contract # AB80188N

$^{(1)}$ Porosity using Specific Gravity, $^{(2)}$ Porosity using volumetric method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21270	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-10B
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.014			Tare No.	675-C	
2	3.025	Top	2.791	Tare Weight	9.61	*grams*
3	3.036	Bottom	2.789	Wet Weight + Tare	630.65	*grams*
Average	3.03	Average	2.790	Dry Weight + Tare	618.71	*grams*
				Moisture Content	2.0	%

Total Weight of Soil + Tube Section	618.71	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.36	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	2.0	%
Wet Density	127.4	*pcf*
Dry Density	125.0	*pcf*
Specific Gravity	2.513	
Porosity$^{(1)}$	0.20	
Porosity$^{(2)}$	0.17	

Remarks: Task Order # 27
Contract # AB80188N
$^{(1)}$ Porosity using Specific Gravity, $^{(2)}$ Porosity using volumetric Method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21271	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-11 B
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.076			Tare No.	SGL-5C	
2	3.074	Top	2.792	Tare Weight	9.60	*grams*
3	3.082	Bottom	2.787	Wet Weight + Tare	652.07	*grams*
Average	3.08	Average	2.790	Dry Weight + Tare	637.21	*grams*
				Moisture Content	2.4	%

Total Weight of Soil + Tube Section	637.21	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.40	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	2.4	%
Wet Density	129.1	*pcf*
Dry Density	126.1	*pcf*
Specific Gravity	2.53	
Porosity$^{(1)}$	0.20	
Porosity$^{(2)}$	0.19	

Remarks: Task Order # 27
Contract # AB80188N
$^{(1)}$ Porosity using Specific Gravity, $^{(2)}$ Porosity using Volumetric method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21272	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-12B
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.11			Tare No.	SGL-6C	
2	3.11	Top	2.804	Tare Weight	9.73	*grams*
3	3.114	Bottom	2.804	Wet Weight + Tare	667.19	*grams*
Average	3.11	Average	2.804	Dry Weight + Tare	651.76	*grams*
				Moisture Content	2.4	%

Total Weight of Soil + Tube Section	642.03	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.42	*lbs*
Volume of Sample	0.011	*ft*^{3}

RESULT SUMMARY

Moisture Content	**2.4**	%
Wet Density	**127.3**	*pcf*
Dry Density	**124.3**	*pcf*
Specific Gravity	**2.44**	
Porosity(1)	**0.18**	
Porosity(2)	**0.16**	

Remarks: Task Order # 27
Contract # AB80188N
(1)Porosity using Specific Gravity (2)Porosity using Volumetric method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21277	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-027A1
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.373			Tare No.		
2	2.374	Top	2.975	Tare Weight	0.00	*grams*
3	2.372	Bottom	2.975	Wet Weight + Tare	576.50	*grams*
Average	2.37	Average	2.975	Dry Weight + Tare	522.90	*grams*
				Moisture Content	10.3	%

Total Weight of Soil + Tube Section	576.50	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.27	*lbs*
Volume of Sample	0.010	*ft³*

RESULT SUMMARY

Moisture Content	10.3	%
Wet Density	133.1	*pcf*
Dry Density	120.8	*pcf*
Specific Gravity	2.38	
Porosity(1)	0.19	
Porosity(2)	0.19	

Remarks: Task Order # 27
Contract # AB80188N
(1) Porosity using The Specific Gravity, (2) Porosity Using the Volumetric Method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21278	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-028A1
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.519			Tare No.		
2	2.518	Top	3.003	Tare Weight	0.00	*grams*
3	2.52	Bottom	3.002	Wet Weight + Tare	609.16	*grams*
Average	2.52	Average	3.003	Dry Weight + Tare	536.17	*grams*
				Moisture Content	13.6	%

Total Weight of Soil + Tube Section	609.17	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.34	*lbs*
Volume of Sample	0.010	*ft³*

RESULT SUMMARY

Moisture Content	**13.6**	%
Wet Density	**130.1**	*pcf*
Dry Density	**114.5**	*pcf*
Specific Gravity	**2.44**	
Porosity(1)	**0.25**	
Porosity(2)	**0.25**	

Remarks: Task Order # 27
Contract # AB80188N
(1) Porosity using the Specific Gravity, (2) Porosity using the Volumetric Method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No.:	21273	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-029A2
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
				Tare No.		
1	2.589					
2	2.589	Top	2.994	Tare Weight	0.00	*grams*
3	2.589	Bottom	2.994	Wet Weight + Tare	624.27	*grams*
Average	2.59	Average	2.994	Dry Weight + Tare	548.04	*grams*
				Moisture Content	13.9	%

Total Weight of Soil + Tube Section	624.57	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.38	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	13.9	%
Wet Density	130.5	*pcf*
Dry Density	114.6	*pcf*
Specific Gravity	2.43	
Porosity(1)	0.24	
Porosity(2)	0.23	

Remarks:
Task Order # 27
Contract # AB80188N
(1)Porosity using specific Gravity. Porosity using Volumetric method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21274	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-030A2
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.569			Tare No.		
2	2.569	Top	3.013	Tare Weight	0.00	*grams*
3	2.569	Bottom	3.013	Wet Weight + Tare	617.00	*grams*
Average	2.57	Average	3.013	Dry Weight + Tare	543.09	*grams*
				Moisture Content	13.6	%

Total Weight of Soil + Tube Section	617.00	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.36	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	13.6	%
Wet Density	128.3	*pcf*
Dry Density	113.0	*pcf*
Specific Gravity	2.42	
Porosity(1)	0.25	
Porosity(2)	0.25	

Remarks: Task Order # 27
Contract # AB80188N
(1)Porosity using the Specific Gravity. (2)Porosity using the Volumetric Method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No:	21275	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-031A2
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.513			Tare No.		
2	2.512	Top	2.998	Tare Weight	0.00	*grams*
3	2.514	Bottom	2.997	Wet Weight + Tare	602.70	*grams*
Average	2.51	Average	2.998	Dry Weight + Tare	531.38	*grams*
				Moisture Content	13.4	%

Total Weight of Soil + Tube Section	602.70	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.33	*lbs*
Volume of Sample	0.010	ft^3

RESULT SUMMARY

Moisture Content	13.4	%
Wet Density	129.5	*pcf*
Dry Density	114.1	*pcf*
Specific Gravity	2.41	
Porosity$^{(1)}$	0.24	
Porosity$^{(2)}$	0.24	

Remarks: Task Order # 27
Contract # AB80188N
$^{(1)}$ Porosity using Specific Gravity, $^{(2)}$ Porosity using the Volumetric Method

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GTX TECHNICAL PROCEDURE T-03
UNIT WEIGHT OF SAMPLE

Project No.:	GTX-1238	Boring No.:	N/A
Lab No.:	21276	Depth:	N/A
Project Name:	Tank Closure Grout Testing Projec	Sample ID:	TNK-032A2
Tested By:	MM	Reviewed By:	MM
Date:	05/25/07	Date:	06/01/07

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.541			Tare No.		
2	2.542	Top	2.996	Tare Weight	0.00	*grams*
3	2.541	Bottom	2.995	Wet Weight + Tare	613.40	*grams*
Average	2.54	Average	2.996	Dry Weight + Tare	540.00	*grams*
				Moisture Content	13.6	%

Total Weight of Soil + Tube Section	613.40	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.35	*lbs*
Volume of Sample	0.010	ft^3

RESULT SUMMARY

Moisture Content	13.6	%
Wet Density	130.5	*pcf*
Dry Density	114.9	*pcf*
Specific Gravity	2.43	
Porosity[(1)]	0.24	
Porosity[(2)]	0.24	

Remarks: Task Order # 27
Contract # AB80188N
[(1)]Porosity using the Specific Gravity, Porosity using the volumetric Method

APPENDIX B. INL REPORT ON TESTING OF REDUCING FILL GROUT

Idaho National Laboratory

May 23, 2007

CCN 209883

Kenneth L. Dixon
Savannah River National Laboratory
Building 773-42A
Aiken, SC 29808

SUBJECT: Data Report for Savannah River Site - FTF Reducing Grout Cores (INL/MIS-06-11865)

Dear Kenneth:

Scope

Provide testing and consulting services for Grout samples.

Introduction

Two grout cores identified as TNK019R and TNK020R were received by the Idaho National Laboratory for hydraulic analyses from the Savannah River Site (SRS). The cores were laboratory casts of reducing grout material that was cured in polybutyrate plastic tubes. The tubes had dimensions of approximately 2.5 cm diameter by ~30 cm long. All cores were received in good shape with no visual fracturing or significant drying noted upon receipt. Requested analysis included: dry bulk density, porosity, moisture retention characteristics, saturated and unsaturated hydraulic conductivity measurements, and van Genuchten parameters.

Sample Preparation

To expedite testing, the two 30 cm long grout cores were cut into a number of lengths for laboratory analyses using a diamond tipped masonry saw. The first set of sub-cores was used for permeability analysis using both the standard falling head and the centrifuge methods. The second set of sub-cores was used to determine the dry bulk density, porosity, moisture retention characteristics, and van Genuchten parameters of the grout material.

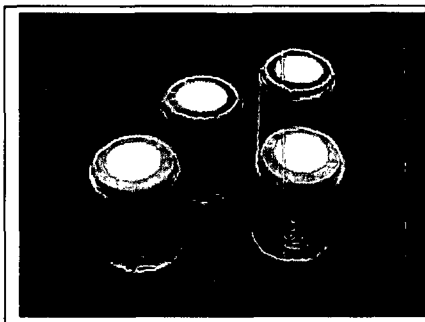

Figure 1. Grout samples potted in epoxy casts for permeability analyses.

The four sub-cores used in the permeability analysis required potting these samples in an epoxy mixture to establish a no flow boundary along the length of the sub-core and provide a uniform outer diameter for hydraulic conductivity testing (Figure

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1). In general, the length of the permeability sub-core was initially cut to 6 cm in length to facilitate potting the core in our UFA mold. The cores were centered in the 3.3 cm diameter Teflon mold, and filled with a two part epoxy molding compound. After curing (~24 to 48 hours), the mold was split open to extract the potted cement material. The ends of the potted material were then trimmed to a length appropriate for the UFA using a masonry saw (~.5 cm in length).

Potting of the grout samples for hydraulic flow testing followed procedures developed for the previously tested SRNL saltstone cores. Ceramic epoxy is typically not used as a casting compound but, in our case, the small volume of ceramic epoxy required for each mold was such that heat generation was not an issue.

Potting sub-cores into epoxy for dry bulk density, porosity, and moisture characteristic measurements was not necessary. These sub-cores were also cut from the 30 cm samples as thin (~0.8 cm height) disks (see Figure 2 for examples). To expedite testing, 10 sub-cores were cut from each core and were used to determine various portions of the moisture retention curve. Four sub-cores were used in the wet end (i.e., hanging column analysis) of the moisture retention curve development and 4 sub-cores were used in the mid range (i.e., pressure plate analysis). The remaining two sub-cores were tested as replacement cores but not evaluated as to their hydraulic properties. Four of the pressure plate sub-cores (two from each sample) were used to determine the high range of the moisture retention curve (i.e., chilled mirror analysis).

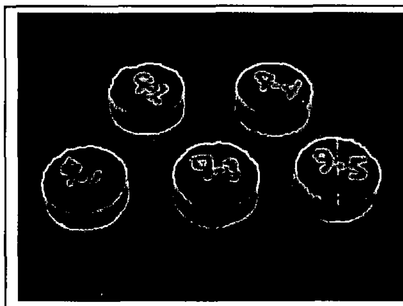

Figure 2. Example of grout samples used in moisture retention analyses.

The wetting solution was a mixture of $CaCl_2$, Na_2SO_4, $MgCl_2$, KCl, and NaCl salts mixed in nanopure DI water to create an "SRNL Artificial Ground Water" as per instruction send via email. The recipe followed that described by Storm and Kaback, (1992).

Methods

Dry bulk density is expressed as the mass per unit volume of material. Procedures followed those described in Method of Soil Analysis where the total volume of a porous material is measured, then dried in an oven at 105° C to determine the dry porous material mass. For the sub-cores, the diameter and length of each sub-core was measured with a caliper to determine its volume. The sub-cores were dried in an oven over 48 hours to a constant weight. Dividing the mass by its volume gives its bulk density. Sub-core samples from the hanging column and the pressure plate analyses were used to calculate an average bulk density.

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Vacuum saturation was performed following procedures described by Flint and Flint (Method of Soil Analysis, chapter 2.3, pg 233). No pre-flushing with CO_2 was performed. A plastic desiccant chamber was used as the vacuum chamber. The samples were placed in the chamber, a vacuum was applied for approximately 3 hours, then water was added to the base of the samples to allow them to imbibe the solution. Vacuum saturation lasted approximately 5 days.

Saturated water porosity can be determined directly or can be calculated as a fitting parameter from the van Genuchten analysis of the moisture retention data. In a typical soil hydraulic analysis, the weight of the samples immediately at the termination of the falling head method is used to calculate the saturated water porosity. For the reducing grout samples, we had to pot the samples in an epoxy cast of an unknown weight that would cause some uncertainty in the porosity calculation. Therefore, we determined the saturated water porosity of the moisture retention sub-cores after vacuum saturation.

Saturated hydraulic conductivity measurements were attempted on the potted sub-cores using the falling head method outlined in ASTM D5084 and those described by Reynolds and Elrick in Methods of Soil Analysis, Chapter 3.4.2.3. Saturated hydraulic conductivities were also determined using the falling head method in the UFA following the methods of Nimmo et.al. (MOSA pg 903). This testing is similar to the standard falling head method but uses the centrifuge to increase the fluid driving force through the sample. Previous testing on saltstone samples confirmed that the falling head centrifuge method agreed with the standard falling head results.

Saturated hydraulic conductivity analysis in a centrifuge takes the following form with both a gravity and centrifugal driving force:

$$K_{sat} = \frac{aL}{A(t_2 - t_1)} * \ln\left(\frac{gh_1 + 0.5\omega^2 r^2}{gh_2 + 0.5\omega^2 r^2}\right) \qquad (1)$$

where:

a is the area of the burette
L is the sample length
A is the area of the sample
t is time
g is gravity
H is the height of the water column
w is the rotational speed
r is the centrifuge radius

Unsaturated hydraulic conductivity testing could not be performed in the Unsaturated Flow Apparatus (UFA) model J-6 due to the low saturated hydraulic conductivity of the reducing grout material. Nimmo discusses the steady state centrifuge method in Methods of Soil Analysis, Chapter 3.6.1.1.b and methods generally followed those outlined in ASTM D6527. To conduct an unsaturated hydraulic conductivity test, a constant flux is applied on the upper surface of the epoxy potted sample. The flux rate is typically set to approximately ½ of the measured saturated hydraulic conductivity. The sample is then spun at 500 to 3000 RPM in the UFA centrifuge. The flux from the centrifuge falling head test was to low to apply with certainty using syringe pumps.

Moisture retention characteristics measurements describe a porous media pore size distribution through relating the amount of water retained by a porous media at known matric potentials. The data for the reducing grout sub-cores were carried out by 3 separate methods.

To obtain data near saturation, we used the hanging column apparatus. Saturated samples were placed in contact with a highly porous ceramic plate that is connected to a water column and reservoir where the water surface is beneath the sample. (see MOSA pg 146). The distance between the water surface and the sample is the imposed suction on the sample (i.e. the matric potential). A series of steps consisting of lowering the level of the reservoir and measuring the equilibrium weight of the sample were conducted.

For the mid-matric potentials, we used the pressure plate method (Method of Soil Analysis, 2002, chapter 3.3.2.4) in a Soil Moisture 15 bar pressure plate extractor (model 1500). Sample weights were recorded on small ~1 cm high sub-cores at 0.8, 3.5 and 12.5 bars of pressure. Moisture contents were calculated from the oven dried weights measured at the end of the test.

Moisture contents at higher soil water potentials (~40 bars) were measured using the chilled mirror method (Method of Soil Analysis, 2002, chapter 3.3.2.9.b) with the WP4 meter. Samples from the pressure plate method were used for these analyses. After the completion of the pressure plate measurements, the samples were placed in the WP4 sample chamber and allowed to evaporate until equilibrium was reached between the sample humidity and the matric potential of the porous material. The humidity was then measured using the WP4 chilled mirror humidity sensor to determine the equivalent matric potential and the sample was weighed to determine its corresponding moisture content.

Hydraulic transport parameters (*van Genuchten parameters* alpha, n, and residual moisture content) were fitted to the moisture retention data. The saturated porosity was not fitted. Data were analyzed using the RETC fitting program.

Results and Discussion

The results appear to be reasonable and generally consistent with one another. The following tables and paragraphs list the measurement results and provide a general discussion of the results. Sample numbers were assigned to each of the subcores. For example, 19 – 1, indicates it was taken from TNK019R and is sub-core number 1 that was used for the moisture retention measurements. A dash between the sub-core number means the analysis was an average of the sub-cores. For the potted samples, sample 19A indicates that it was an epoxy coated sub-core used for hydraulic analysis and was taken from TNK019R.

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Bulk Density

The dry bulk densities ranged from 1.81 to 1.84 g cm^{-3}. The sample geometries were small and not perfectly round or cut perfectly parallel, resulting in some uncertainty of the volume calculation for bulk density analysis; however, this uncertainty is not believe to be significant. The bulk densities measured for sample TNK019R were slightly higher than those measured for TNK020R. Since both samples were cast from the same grout mix, the variation in bulk density may be an artifact of sample preparation.

Sample #	Average bulk density (g cm^{-3})
19 – 1-5	1.835
19 – 6-10	1.843
20 – 1-5	1.815
20 – 6-10	1.810

Moisture Retention Data

Saturated moisture contents were consistent for the reducing grout sub-cores. Saturated moisture content, also known as the saturated porosity, varied from 0.264 to 0.272 cm^3 cm^{-3}.

Sample #	19 – 1-2 & 6-7		19 – 3-4 & 8-9		20 – 1-2 & 6-7		20 – 3-4 & 8-9	
Method	Matric Potential (bars)	Moisture Content (cm^3 cm^{-3})	Matric Potential (bars)	Moisture Content (cm^3 cm^{-3})	Matric Potential (bars)	Moisture Content (cm^3 cm^{-3})	Matric Potential (bars)	Moisture Content (cm^3 cm^{-3})
Vacuum Saturation	0	0.264	0	0.267	0	0.272	0	0.268
Hanging Column	0.06	0.261	0.06	0.263	0.06	0.270	0.06	0.268
Hanging Column	0.13	0.261	0.13	0.263	0.13	0.268	0.13	0.265
Pressure Plate	0.78	0.244	0.78	0.247	0.78	0.258	0.78	0.253
Pressure Plate	3.5	0.238	3.5	0.241	3.5	0.253	3.5	0.249
Pressure Plate	12.5	0.233	12.5	0.238	12.5	0.248	12.5	0.244
Chilled Mirror	44.7	0.225	44.7	0.225	34.7	0.242	34.7	0.242

Due to the short turn around time requested, separate pairs of sub-cores were used to generate the hanging column and the pressure plate data. Using separate samples may cause some bias in the data; however, it is assumed that due to the homogeneous nature of the grout, separate samples will cause little problems. The chilled mirror data were obtained from measurements of samples 19-6, 19-7, 20-6, and 20-7 and used to help anchor the tail of the moisture retention curve. Sub-core sample data pairs were average to develop a single chilled mirror matric potential – moisture content data point for each sample (i.e. 19-6 and 19-7 values were averaged and used for both sets of TNK019R sub-cores.

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See the van Genuchten analysis for graphs of the data as a function of moisture content and pressure head (matric potential).

van Genuchten Parameter Analysis

The moisture retention data (see moisture retention data result section) was used to develop the van Genuchten transport parameter for the grout sub-cores. All moisture retention values were given a weight of 1. The residual moisture was set to be a regressed number and we used the standard Mualem relationship between n and m (i.e., m = 1 – 1/n). Figures 3a) and 3b) illustrates the data as a function of water content verses pressure head (matric potential) and the van Genuchten fitted relationship using all the data for both grout cores shipped. The bold values in the table below were determined using both sets of data for the sample and likely best represent the hydraulic parameters determined by this method.

	(cm-1)	n (-)	$_r$ (cm^3 cm^{-3})	$_s$ (cm^3 cm^{-3})	K_{sat} (cm s^{-1})
19 – (1/2-6/7)	0.00621	1.261	0.215	0.264	9x10^{-11}
19 – (3/4-8/9)	0.01195	1.062	0.143	0.267	4x10^{-10}
TNK019R	**0.00733**	**1.229**	**0.215**	**0.266**	**2.5x10^{-10}**
20 – (1/2-6/7)	0.00074	1.286	0.222	0.272	5x10^{-10}
20 – (3/4-8/9)	0.00468	1.486	0.240	0.268	5x10^{-10}
TNK020R	**0.0104**	**1.229**	**0.233**	**0.270**	**5x10^{-10}**

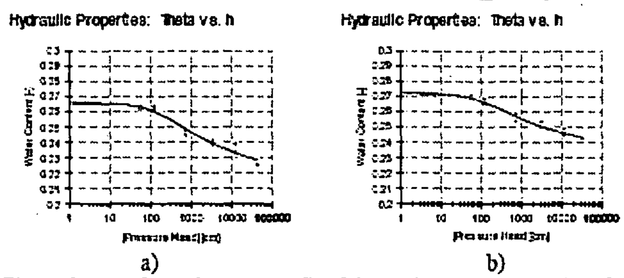

Figure 3. van Genuchten curve fit of the moisture retention data for a) TNK019R and b) TNK020R

Hydraulic Conductivity

Measured saturated hydraulic conductivity values ranged from the 5×10^{-10} to 9×10^{-11} cm s^{-1}. Hydraulic conductivity determination was attempted using the traditional falling head method with approximately 2 meters of applied head. The lower limit of this method for determining saturated hydraulic conductivity is approximately 10^{-8} cm s^{-1}. The reducing grout sub-cores had such low synthetic groundwater fluxes that accurate determination of the hydraulic conductivity was not possible with the traditional falling head method. In the table, we represent this limitation by indicating the hydraulic conductivity to be less than 10^{-8} cm s^{-1}. To increase the driving force on the water, we used the centrifuge falling head method in the UFA centrifuge. Previously tested saltstone analyses indicated that the centrifuge falling head method is much quicker and is a better method for analyses of 'tight' samples. These samples were spun for over 100 hours at 2500 rpms to obtain sufficient flux of water through the grout samples.

Method	Sample ID	Ksat (cm s^{-1})
Standard Falling Head	19-A	<1E-08
Centrifuge Falling Head	19-A	9E-11
Standard Falling Head	19-B	<1E-08
Centrifuge Falling Head	19-B	4E-10
Standard Falling Head	20-A	<1E-08
Centrifuge Falling Head	20-A	5E-10
Standard Falling Head	20-B	<1E-08
Centrifuge Falling Head	20-B	5E-10

Unsaturated hydraulic conductivities were not directly measured using the UFA centrifuge since the fluid flux necessary to perform these analyses was too low to be accurately controlled. Considering the small drainage measured in the moisture retention analyses a conservative assumption would be to assume that the unsaturated hydraulic conductivity is equal to the saturated hydraulic conductivity value over the range of matric potential measured. Otherwise, the unsaturated hydraulic conductivity values as estimated by the van Genuchten parameter analysis method can be used.

Suggested Future Work

Below are a few notes on the testing and some suggested activities to address the issues raised by this round of laboratory analyses.

1. The grout material between TNK019R and TNK020R are close in hydraulic properties but do exhibit a slight but consistent bias in the data. TNK019R has a higher bulk density, lower saturated porosity, smaller saturated hydraulic conductivity, and a smaller alpha than TNK020R. The material visually looks identical and this slight variability may be due to variation in sample preparation.

2. The reducing grout material exhibits a very low hydraulic conductivity approaching the limits of the testing equipment. If future grouts are expected to be of similar hydraulic properties, we may consider reducing the length of the epoxy potted samples in an attempt to increase the pressure gradient.

Sincerely,

Earl D. Mattson

Earl D. Mattson, Research Hydrologist
Geosciences

EDM:mab

APPENDIX C. STRENGTH REPORTS

ASR 18-335 (06/01)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 192-(02) ASTM C 617-(98(03))

ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04) ASTM C 231-(04) ASTM C 1064-(05)

ASTM D 6103-(04)

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Report No.:	2007-	Date Molded:	2/21/2007	Work Package No.:	N/A
Report Date:	2/21/2007	Time Molded:		QCIR No.:	N/A
Project No.:	LSWDSMOD	Mix Design:	B2000-X-O-O-BS**	Design Strength:	2000 psi @ 90 days
TWC: N/A	Design Category: N/A	Batch Ticket Number:	N/A	Placement Method: N/A	Contractor: N/A
Supplier:	LaFarge	Type Admixture(s), (if known):	N/A		
Placement Location:	CAST IN LAB, BLDG. 717-5N				

Acceptance Criteria:	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
Criteria	N/A	3 to 6 +/- 1	N/A	Max. 90
Result	N/A	N/A	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	N/A	N/A / N/A	N/A	N/A / N/A

Weather: INDOORS

Inspector: ______ Level ___ Initial Curing: Conforming / ______ Ambient Temp., °F: ___

Inspector: ______ Level ___ Laboratory Curing: Conforming CDS-167 /

Pick-up Date: ______ Time: ______ Initials: ___ Cast in Lab.: Yes x No ☐

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070025.1	14	3/7/2007	6.28	3.00	7.07	11073	1570			X			
	28	3/21/2007	6.10	3.00	7.07	10770	1520			X			
	62	4/24/2007	6.15	3.00	7.07	13982	1980				X		
	62	4/24/2007	5.80	3.00	7.07	14896	2110				X		
	90	5/22/2007	6.10	3.00	7.07	14641	2070			X			
	90	5/22/2007	6.08	3.00	7.07	14924	2110				X		
	180	8/20/2007	6.10	3.00	7.07	14900	2110			X			

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M& TE Cal.: SC- N/A N/A TG- ______ AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- ______ TM- 5 ______

Remarks: 28 DAY AVG. =

*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

**Mix4-Mod4 page15

***get from hold cylinders

Procedure No.:	C-QCP-020	Drawing No.:	N/A	Specification No.:	C-SPS-G-00085
Rev.: N/A	PCN: N/A	Rev.: N/A	DCF: N/A	Rev.: N/A	DCF: N/A

Inspector: ______ Level ___ Date: ______ NCR No.: N/A Test Results: *N/A

Reviewer: ______ Level ___ Date: ______ Inspector: ______ Level ___ Date: ______

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 192-(02) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(04)

Page 2 of 2

Report No.: 2007- | Date Molded: 2/21/2007 | Work Package No.: N/A
Report Date: 2/21/2007 | Time Molded: | QCIR No.: N/A
Project No.: LSWDSMOD | Mix Design: B2000-X-O-O-BS** | Design Strength: 2000 psi, @ 90 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp. °F
Criteria	N/A	3 to 6 +/- 1	N/A	Max 90
	N/A	N/A	N/A	70

Truck I.D.: N/A | Time of Mixing: N/A | Time Start/Stop Discharge: N/A / N/A | Batch Size, yds.: N/A | Water Allow. / Water Added, gals.: N/A / N/A | Weather: INDOORS

Inspector: ____ Level ____ Initial Curing: Conforming / ____ Ambient Temp., °F: ____
Inspector: ____ Level ____ Laboratory Curing: Conforming CDS-167 /

Pick-up Date: ____ Time: ____ Initials: ____ Cast in Lab.: Yes [x] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070025.1	180	8/20/2007	6.08	3.00	7.07	14510	2050			X			
8 HOLDS LEFT	***?	2/21/2007											
	***?	2/21/2007											
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M&TE Cal.: SC- N/A N/A TG- ____ AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- ____ TM- 5 ____

Remarks: 28 DAY AVG. =
*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY
**Mix4-Mod4 page15
***get from hold cylinders

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A
Inspector: ____ Level ____ Date: ____ NCR No.: N/A | Test Results: *N/A
Reviewer: ____ Level ____ Date: ____ Inspector: ____ Level ____ Date: ____

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 192-(02) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(04)

Page 1 of 1

Report No.: 2007-
Date Molded: 2/21/2007
Work Package No.: N/A
Report Date: 2/21/2007
Time Molded:
QCIR No.: N/A
Project No.: LSWDSMOD
Mix Design: B2000-X-O-O-BS**
Design Strength: 2000 psi @ 90 days
TWC: N/A
Design Category: N/A
Batch Ticket Number: N/A
Placement Method: N/A
Contractor: N/A
Supplier: LaFarge
Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB. BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
Criteria	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.: N/A
Time of Mixing: N/A
Time Start/Stop Discharge: N/A / N/A
Batch Size, yds.: N/A
Water Allow. / Water Added, gals.: N/A / N/A
Weather: INDOORS
Inspector: Level
Initial Curing: Conforming /
Ambient Temp., °F:
Inspector: Level
Laboratory Curing: Conforming CDS-167 /
Pick-up Date: Time: Initials:
Cast in Lab: Yes x No

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070025.2	14	3/7/2007	6.22	3.00	7.07	6523	920			X			
	28	3/21/2007	6.05	3.00	7.07	7476	1060			X			
	62	4/24/2007	6.00	3.00	7.07	8321	1180				X		
	62	4/24/2007	6.00	3.00	7.07	8189	1160				X		
	90	5/22/2007	5.95	3.00	7.07	8223	1160				X		
	90	5/22/2007	6.02	3.00	7.07	8304	1170	X					
	***180	8/20/2007	6.00	3.00	7.07	8240	1170				X		

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M&TE Cal.: SC- N/A N/A TG- AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- TM- 5

Remarks: 28 DAY AVG. =

*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

**Mix 5 - Mod 4 page 16

***NO HOLD CYLINDERS LEFT. ONLY ONE BREAK FOR 180 DAY

Procedure No.: C-QCP-020
Drawing No.: N/A
Specification No.: C-SPS-G-00085
Rev.: N/A PCN: N/A
Rev.: N/A DCF: N/A
Rev.: 7 DCF: N/A
Inspector: Level Date: NCR No.: N/A Test Results: *N/A
Reviewer: Level Date: Inspector: Level Date:

ASR 18-335 (06/01)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 192-(02) ASTM C 617-(98(03))
ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04) ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(04) Page 1 of 2

Report No.: 2007- | Date Molded: 2/22/2007 | Work Package No.: N/A
Report Date: 2/22/2007 | Time Molded: | QCIR No.: N/A
Project No.: LSWDSMOD | Mix Design: ** | Design Strength: 2000 psi @ 90 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.: N/A | Time of Mixing: N/A | Time Start/Stop Discharge: N/A / N/A | Batch Size, yds.: N/A | Water Allow. / Water Added, gals.: N/A / N/A
Weather: INDOORS
Inspector: ______ Level ___ Initial Curing: Conforming ___ / ___ Ambient Temp., °F:
Inspector: ______ Level ___ Laboratory Curing: Conforming ___ / ___
Pick-up Date: ______ Time: ______ Initials: ___ Cast in Lab.: Yes [x] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070027.1	14	3/8/2007	6.20	3.00	7.07	7006	990	X					
	28	3/22/2007	6.08	3.01	7.12	12497	1760				X		
	61	4/24/2007	6.00	3.00	7.07	16848	2380				X		
	61	4/24/2007	5.95	3.00	7.07	16031	2270				X		
	90	5/23/2007	5.88	3.00	7.07	17442	2470				X		
	90	5/23/2007	6.05	3.00	7.07	16292	2300				X		
	180	8/21/2007	6.06	3.00	7.07	17310	2450	X					

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M&TE Cal.: SC- N/A N/A | TG- | AM- N/A N/A | UWB- N/A N/A | S- N/A N/A | CDS- | TM- 5

Remarks: 28 DAY AVG. =
*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY
** Reducing Grout OPD-EXE-X-P-O-BS : Batch 1

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A
Inspector: ______ Level ___ Date: ______ NCR No.: N/A | Test Results: *N/A
Reviewer: ______ Level ___ Date: ______ Inspector: ______ Level ___ Date: ______

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 192-(02) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(04)

Page 2 of 2

Report No.: 2007- | Date Molded: 2/22/2007 | Work Package No.: N/A

Report Date: 2/22/2007 | Time Molded: | QCIR No.: N/A

Project No.: LSWDSMOD | Mix Design: ** | Design Strength: 2000 psi @ 90 days

TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A

Supplier: LaFarge | Type Admixture(s), (if known): N/A

Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria:	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	N/A	N/A / N/A	N/A	N/A / N/A

Weather: INDOORS

Inspector: Level | Initial Curing: Conforming / | Ambient Temp., °F:

Inspector: Level | Laboratory Curing: Conforming | CDS-167 /

Pick-up Date: | Time: | Initials: | Cast in Lab.: Yes x No

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070027.1 9 HOLD CYLINDERS LEFT	150	8/21/2007	6.08	3.00	7.07	17020	2410	X					
	***?	2/22/2007											
	***?	2/22/2007											
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M&TE Cal.: SC- N/A N/A | TG- | AM- N/A N/A | UWB- N/A N/A | S- N/A N/A | CDS- | TM- 5

Remarks:
28 DAY AVG. =
*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY
** Reducing Grout OPD-EXE-X-P-O-BS : Batch 1
***get from hold cylinders

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085

Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A

Inspector: Level Date: | NCR No.: N/A | Test Results: *N/A

Reviewer: Level Date: | Inspector: Level Date:

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04)

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ASTM C 192-(02) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(04)

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Report No.: 2007- | Date Molded: 2/22/2007 | Work Package No.: N/A
Report Date: 2/22/2007 | Time Molded: | QCIR No.: N/A
Project No.: LSWDSMOD | Mix Design: ** | Design Strength: 2000 psi @ 90 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria:	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
Criteria	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.: N/A | Time of Mixing: N/A | Time Start/Stop Discharge: N/A / N/A | Batch Size, yds.: N/A | Water Allow. / Water Added, gals.: N/A / N/A | Weather: INDOORS
Inspector: Level Initial Curing: Conforming / Ambient Temp., °F:
Inspector: Level Laboratory Curing: Conforming CDS-167 /
Pick-up Date: Time: Initials: Cast in Lab.: Yes x No

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070027.2	14	3/8/2007	6.10	3.00	7.07	7038	1000	X					
	28	3/22/2007	6.12	3.01	7.12	11782	1660				X		
	61	4/24/2007	6.08	3.00	7.07	15116	2140				X		
	61	4/24/2007	6.05	3.00	7.07	15048	2130				X		
	90	5/23/2007	6.08	3.00	7.07	15571	2200		X				
	90	5/23/2007	6.03	3.00	7.07	15879	2250			X			
	180	8/21/2007	5.90	3.00	7.07	16860	2390				X		

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?.	0

M& TE Cal.: SC- N/A N/A TG- AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- TM- 5

Remarks: 28 DAY AVG. =
*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY
** Reducing Grout Mix 1, Batch 2

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A
Inspector: Level Date: NCR No.: N/A Test Results: *N/A
Reviewer: Level Date: Inspector: Level Date:

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04)

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ASTM C 192-(02) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(04)

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Report No.: 2007- | Date Molded: 2/22/2007 | Work Package No.: N/A
Report Date: 2/22/2007 | Time Molded: | QCIR No.: N/A
Project No.: LSWDSMOD | Mix Design: ** | Design Strength: 2000 psi @ 90 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB. BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
Criteria	N/A	3 to 6 +/- 1	N/A	Max. 90
Result	N/A	N/A	N/A	70

Truck I.D.: N/A | Time of Mixing: N/A | Time Start/Stop Discharge: N/A / N/A | Batch Size, yds.: N/A | Water Allow. / Water Added, gals.: N/A / N/A
Weather: INDOORS
Inspector: | Level | Initial Curing: Conforming /
Ambient Temp., °F:
Inspector: | Level | Laboratory Curing: Conforming | CDS-167 /
Pick-up Date: | Time: | Initials: | Cast in Lab.: Yes [x] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070027.2 2 HOLD CYLINDERS LEFT	180	8/21/2007	6.10	3.00	7.07	7038	1000			X			
	***?	2/22/2007											
	***?	2/22/2007											
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						
		N/A					N/A						

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M&TE Cal.: SC- N/A N/A | TG- | AM- N/A N/A | UWB- N/A N/A | S- N/A N/A | CDS- | TM- 5

Remarks: 28 DAY AVG. =

*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

** Reducing Grout Mix 1, Batch 2

***get from hold cylinders

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A
Inspector: | Level | Date: | NCR No.: N/A | Test Results: *N/A
Reviewer: | Level | Date: | Inspector: | Level | Date:

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 192-(02) ASTM C 617-(98(03))
ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04) ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(04p)

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Report No.: 2007- | Date Molded: 5/08/2007 | Work Package No.: N/A
Report Date: 5/08/2007 | Time Molded: 1400 | QCIR No.: N/A
Project No.: LSWDSMOD | Mix Design: ** | Design Strength: 2000 psi @ 28 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s). (if known): N/A
Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	N/A	N/A / N/A	N/A	N/A / N/A

Weather: INDOORS
Inspector: ______ Level ___ Initial Curing: Conforming / Ambient Temp., °F:
Inspector: ______ Level ___ Laboratory Curing: Conforming CDS-167 / 9/13/07
Pick-up Date: ______ Time: ______ Initials: ______ Cast in Lab.: Yes [x] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070070	28	6/5/2007	6.10	3.00	7.07	24641	3490				X		
	28	6/5/2007	6.18	3.00	7.07	23913	3380				X		
	90	8/6/2007	6.09	3.00	7.07	32490	4600	X					
	90	8/6/2007	6.12	3.00	7.07	35890	5080	X					
	181	11/5/2007											
9 HOLDS	181	11/5/2007											
	90 HOLD	8/6/2007											

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M& TE Cal.: SC- N/A N/A TG- ______ AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- ______ TM- 5

Remarks: 28 DAY AVG. =

*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

** #8 Stone Reducing Grout with Advaflex #1A

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: N/A | DCF: N/A
Inspector: ______ Level ___ Date: ______ NCR No.: N/A Test Results: *N/A
Reviewer: ______ Level ___ Date: ______ Inspector: ______ Level ___ Date: ______

ASR 18-335 (06/01)

ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 192-(02) ASTM C 617-(98(03))
ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04) ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(04)

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Concrete/CLSM Test Report

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Report No.:	2007-	Date Molded:	3/21/2007	Work Package No.:	N/A
Report Date:	3/21/2007	Time Molded:	1450	QCIR No.:	N/A
Project No.:	LSWDSDMOD	Mix Design:	Reducing Grout with SIKA-1A	Design Strength:	2000 psi @ 90 days
TWC: N/A	Design Category: N/A	Batch Ticket Number:	N/A	Placement Method: N/A	Contractor: N/A
Supplier:	LaFarge	Type Admixture(s), (if known):	N/A		

Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria:	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	N/A	N/A / N/A	N/A	N/A / N/A

Weather: INDOORS

Inspector: Level Initial Curing: Conforming / Ambient Temp., °F:

Inspector: Level Laboratory Curing: Conforming CDS-167 /

Pick-up Date: Time: Initials: Cast in Lab.: Yes [x] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070043	14	4/4/2007	6.10	3.00	7.07	17134	2420				X		
	28	4/18/2007	6.10	3.00	7.07	35875	5080				X		
	28	4/18/2007	6.12	3.00	7.07	37001	5230				X		
	90	6/19/2007	6.08	3.00	7.07	52057	7360			X			
	90	6/19/2007	6.10	3.00	7.07	53493	7570		X				
	180	9/17/2007											
	180	9/17/2007											

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M& TE Cal.: SC- N/A N/A TG- AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- TM- 5

Remarks: 28 DAY AVG. = 5160 psi

*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

FOR INFORMATION ONLY

Procedure No.:	C-QCP-020	Drawing No.:	N/A	Specification No.:	C-SPS-G-00085
Rev.: N/A	PCN: N/A	Rev.: N/A	DCF: N/A	Rev.: 7	DCF: N/A

Inspector: Level Date: NCR No.: N/A Test Results: *N/A

Reviewer: Level Date: Inspector: Level Date:

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ASTM C 39-(04a) ASTM C 31-(03a) ASTM C 143-(05a) ASTM C 192-(02) ASTM C 617-(98(03))
ASTM C 94-(06) ASTM C 138-(01a) ASTM C 172-(04) ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(04)

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Report No.: 2007- | Date Molded: 3/28/2007 | Work Package No.: N/A
Report Date: 3/28/2007 | Time Molded: 1500 | QCIR No.: N/A
Project No.: LSWDSDMOD | Mix Design: Reducing Grout w/ Sika-2 | Design Strength: 2000 psi @ 90 days
TWC: N/A | Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: N/A
Supplier: LaFarge | Type Admixture(s), (if known): N/A
Placement Location: CAST IN LAB, BLDG. 717-5N

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp., °F
	N/A	3 to 6 +/- 1	N/A	Max. 90
	N/A	N/A	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	N/A	N/A / N/A	N/A	N/A / N/A

Weather: INDOORS

Inspector: Level Initial Curing: Conforming / Ambient Temp., °F:
Inspector: Level Laboratory Curing: Conforming CDS-167 /
Pick-up Date: Time: Initials: Cast in Lab.: Yes x No

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
070044	28	4/25/2007	6.00	3.00	7.07	24769	3500		X				
	28	4/25/2007	5.98	3.00	7.07	25483	3610			X			
	90	6/26/2007	5.98	3.00	7.07	38410	5430				X		
	90	6/26/2007	5.99	3.00	7.07	36500	5160				X		
	180	9/24/2007											
9 HOLDS	180	9/24/2007											
	90 HOLD	6/26/2007											

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	?	0

M& TE Cal.: SC- N/A N/A TG- AM- N/A N/A UWB- N/A N/A S- N/A N/A CDS- TM- 5

Remarks: 28 DAY AVG. =
*NOTE: MIX DESIGN, TEST RESULTS SUBMITTED FOR INFORMATION ONLY

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: C-SPS-G-00085
Rev.: N/A | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: 7 | DCF: N/A
Inspector: Level Date: NCR No.: N/A Test Results: *N/A
Reviewer: Level Date: Inspector: Level Date:

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Summary Report of Testing Activities

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[X] Report   [ ] Cover Sheet

Approvals (If required)	Work Package No.: N/A
Civil Materials Testing Supervisor: W. L. Mhyre	QCIR No.: N/A
	Project No.: LSWDSDMOD — TWC: N/A
Quality Programs & Civil Materials Testing Manager: Wyman Pope, Jr.	Design Category: N/A
	Report No.: 2007-LSWDSDMOD-0001 — Date: 5-30-07
Lab No.: N/A	Test Method: ASTMs C 617-98(03) , C 42-04 & C 39-04a
Discipline: Civil Testing	Description: Compressive Strength of a concrete core sample
Location: 717-5N	Reported to: Christine Langton 5-5806

Summary: The concrete core sample from a slab in P-Area had a compressive strength of 2700 psi. The sample had a length of 3.874" and a diameter of 2.785" with a capped height of 4.05". The area of the diameter was 6.09 square inches. The total load on the core was 17,268 pounds and unit load was 2840 psi. Unit Load of 2840 psi was multiplied by the strength correction factor of 0.95 to equal 2700 psi. The pieces of the core were returned to requester after testing.

M&TE: 1)TM-5, 2) TC-5	Cal. Due Date: 1) 12-12-07, 2) 6-12-07	Procedure: C-QCP-020
NCR No.: N/A		Rev: 1
Test Results: [ ] Conforming [ ] Nonconforming [*X] N/A		PCNs: 2
Remarks: * Engineering Evaluation		Specs: N/A
		Rev: N/A
		DCFs: N/A

Inspector: ______ Level: ______ Date: ______

Reviewer: ______ Level: ______ Date: ______

APPENDIX D. RECOMMENDED CHARACTERISTIC CURVES

Table D.1. Recommended Characteristic Curves for the Strong Grout.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 2.1E-08 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999759984985E-01	5.00E-02	9.9999759984985E-01	5.051695E-01
9.9999466348382E-01	1.00E-01	9.9999466348382E-01	4.602615E-01
9.9998813560986E-01	2.00E-01	9.9998813560986E-01	4.127931E-01
9.9996589505087E-01	5.00E-01	9.9996589505087E-01	3.466491E-01
9.9992423067248E-01	1.00E+00	9.9992423067248E-01	2.947121E-01
9.9983184136949E-01	2.00E+00	9.9983184136949E-01	2.420252E-01
9.9951948020069E-01	5.00E+00	9.9951948020069E-01	1.733266E-01
9.9894410984447E-01	1.00E+01	9.9894410984447E-01	1.243930E-01
9.9771146944462E-01	2.00E+01	9.9771146944462E-01	8.083438E-02
9.9392764556881E-01	5.00E+01	9.9392764556881E-01	3.656908E-02
9.8813629837680E-01	1.00E+02	9.8813629837680E-01	1.590808E-02
9.7889352553717E-01	2.00E+02	9.7889352553717E-01	5.462054E-03
9.6197982947142E-01	5.00E+02	9.6197982947142E-01	9.549972E-04
9.4742422763326E-01	1.00E+03	9.4742422763326E-01	2.147589E-04
9.4445614146896E-01	1.15E+03	9.4445614146896E-01	1.571496E-04
9.4149843739237E-01	1.32E+03	9.4149843739237E-01	1.146695E-04
9.3855823799475E-01	1.52E+03	9.3855823799475E-01	8.346626E-05
9.3564165171903E-01	1.75E+03	9.3564165171903E-01	6.062358E-05
9.3275384913103E-01	2.01E+03	9.3275384913103E-01	4.395047E-05
9.2989914876806E-01	2.31E+03	9.2989914876806E-01	3.181163E-05
9.2708110651387E-01	2.66E+03	9.2708110651387E-01	2.299346E-05
9.2430260407322E-01	3.06E+03	9.2430260407322E-01	1.659980E-05
9.2156593350503E-01	3.52E+03	9.2156593350503E-01	1.197164E-05
9.1887287589207E-01	4.05E+03	9.1887287589207E-01	8.626223E-06
9.1622477308579E-01	4.65E+03	9.1622477308579E-01	6.210952E-06
9.1362259209776E-01	5.35E+03	9.1362259209776E-01	4.469033E-06
9.1106698215265E-01	6.15E+03	9.1106698215265E-01	3.213863E-06
9.0855832471098E-01	7.08E+03	9.0855832471098E-01	2.310121E-06
9.0609677694919E-01	8.14E+03	9.0609677694919E-01	1.659837E-06
9.0368230928008E-01	9.36E+03	9.0368230928008E-01	1.192190E-06
9.0131473753344E-01	1.08E+04	9.0131473753344E-01	8.560456E-07
8.9899375041395E-01	1.24E+04	8.9899375041395E-01	6.145234E-07
8.9671893282463E-01	1.42E+04	8.9671893282463E-01	4.410485E-07
8.9448978560139E-01	1.64E+04	8.9448978560139E-01	3.164859E-07
8.9230574215330E-01	1.88E+04	8.9230574215330E-01	2.270671E-07
8.9016618245013E-01	2.16E+04	8.9016618245013E-01	1.628907E-07
8.8807044474630E-01	2.49E+04	8.8807044474630E-01	1.168392E-07
8.8601783538106E-01	2.86E+04	8.8601783538106E-01	8.379902E-08
8.8400763694898E-01	3.29E+04	8.8400763694898E-01	6.009708E-08
8.8203911509369E-01	3.79E+04	8.8203911509369E-01	4.309603E-08
8.8011152414173E-01	4.35E+04	8.8011152414173E-01	3.090260E-08
8.7822411176081E-01	5.01E+04	8.7822411176081E-01	2.215801E-08

Table D.1. Recommended Characteristic Curves for the Strong Grout (Continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 2.1E-08 cm/s)
8.7637612279919E-01	5.76E+04	8.7637612279919E-01	1.588721E-08
8.7456680243901E-01	6.62E+04	8.7456680243901E-01	1.139064E-08
8.7279539877525E-01	7.61E+04	8.7279539877525E-01	8.166486E-09
8.7106116491496E-01	8.76E+04	8.7106116491496E-01	5.854780E-09
8.6936336067584E-01	1.01E+05	8.6936336067584E-01	4.197358E-09
8.6770125395107E-01	1.16E+05	8.6770125395107E-01	3.009075E-09
8.6607412179604E-01	1.33E+05	8.6607412179604E-01	2.157162E-09
8.6448125128394E-01	1.53E+05	8.6448125128394E-01	1.546416E-09
8.6292194016932E-01	1.76E+05	8.6292194016932E-01	1.108575E-09
8.6139549739239E-01	2.03E+05	8.6139549739239E-01	7.946922E-10
8.5990124345141E-01	2.33E+05	8.5990124345141E-01	5.696777E-10
8.5843851066606E-01	2.68E+05	8.5843851066606E-01	4.083722E-10
8.5700664335083E-01	3.08E+05	8.5700664335083E-01	2.927390E-10
8.5560499791435E-01	3.54E+05	8.5560499791435E-01	2.098469E-10
8.5423294289788E-01	4.07E+05	8.5423294289788E-01	1.504258E-10
8.5288985896402E-01	4.68E+05	8.5288985896402E-01	1.078303E-10
8.5157513884484E-01	5.39E+05	8.5157513884484E-01	7.729611E-11
8.5028818725708E-01	6.20E+05	8.5028818725708E-01	5.540810E-11
8.4902842079077E-01	7.13E+05	8.4902842079077E-01	3.971804E-11
8.4779526777651E-01	8.19E+05	8.4779526777651E-01	2.847092E-11
8.4658816813593E-01	9.42E+05	8.4658816813593E-01	2.040866E-11
8.4540657321875E-01	1.08E+06	8.4540657321875E-01	1.462941E-11
8.4424994562976E-01	1.25E+06	8.4424994562976E-01	1.048669E-11
8.4311775904786E-01	1.43E+06	8.4311775904786E-01	7.517092E-12
8.4200949803959E-01	1.65E+06	8.4200949803959E-01	5.388412E-12
8.4092465786855E-01	1.90E+06	8.4092465786855E-01	3.862525E-12
8.3986274430229E-01	2.18E+06	8.3986274430229E-01	2.768737E-12
8.3882327341781E-01	2.51E+06	8.3882327341781E-01	1.984685E-12
8.3780577140654E-01	2.88E+06	8.3780577140654E-01	1.422661E-12
8.3680977437961E-01	3.31E+06	8.3680977437961E-01	1.019791E-12
8.3583482817412E-01	3.81E+06	8.3583482817412E-01	7.310055E-13
8.3488048816081E-01	4.38E+06	8.3488048816081E-01	5.239985E-13
8.3394631905354E-01	5.04E+06	8.3394631905354E-01	3.756119E-13
8.3303189472106E-01	5.80E+06	8.3303189472106E-01	2.692455E-13
8.3213679800113E-01	6.67E+06	8.3213679800113E-01	1.930001E-13
8.3126062051732E-01	7.67E+06	8.3126062051732E-01	1.383460E-13
8.3040296249865E-01	8.82E+06	8.3040296249865E-01	9.916891E-14
8.2956343260213E-01	1.01E+07	8.2956343260213E-01	7.108606E-14
8.2874164773827E-01	1.17E+07	8.2874164773827E-01	5.095577E-14
8.2793723289973E-01	1.34E+07	8.2793723289973E-01	3.652601E-14
8.2714982099305E-01	1.54E+07	8.2714982099305E-01	2.618249E-14
8.2637905267350E-01	1.77E+07	8.2637905267350E-01	1.876808E-14
8.2562457618307E-01	2.04E+07	8.2562457618307E-01	1.345329E-14

Table D.1. Recommended Characteristic Curves for the Strong Grout (Continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 2.1E-08 cm/s)
8.2488604719160E-01	2.35E+07	8.2488604719160E-01	9.643558E-15
8.2416312864101E-01	2.70E+07	8.2416312864101E-01	6.912673E-15
8.2345549059260E-01	3.10E+07	8.2345549059260E-01	4.955126E-15
8.2276281007745E-01	3.57E+07	8.2276281007745E-01	3.551922E-15
8.2208477094978E-01	4.10E+07	8.2208477094978E-01	2.546081E-15
8.2142106374335E-01	4.72E+07	8.2142106374335E-01	1.825075E-15
8.2077138553075E-01	5.43E+07	8.2077138553075E-01	1.308246E-15
8.2013543978562E-01	6.24E+07	8.2013543978562E-01	9.377740E-16
8.1951293624768E-01	7.18E+07	8.1951293624768E-01	6.722129E-16
8.1890359079054E-01	8.25E+07	8.1890359079054E-01	4.818540E-16
8.1830712529235E-01	9.49E+07	8.1830712529235E-01	3.454015E-16
8.1772326750901E-01	1.09E+08	8.1772326750901E-01	2.475898E-16
8.1715175095016E-01	1.25E+08	8.1715175095016E-01	1.774768E-16
8.1659231475764E-01	1.44E+08	8.1659231475764E-01	1.272185E-16
8.1604470358659E-01	1.66E+08	8.1604470358659E-01	9.119243E-17
8.1550866748901E-01	1.91E+08	8.1550866748901E-01	6.536834E-17
8.1498396179973E-01	2.19E+08	8.1498396179973E-01	4.685717E-17
8.1447034702488E-01	2.52E+08	8.1447034702488E-01	3.358805E-17
8.1396758873254E-01	2.90E+08	8.1396758873254E-01	2.407650E-17
8.1347545744589E-01	3.34E+08	8.1347545744589E-01	1.725846E-17
8.1299372853844E-01	3.84E+08	8.1299372853844E-01	1.237117E-17
8.1252218213157E-01	4.41E+08	8.1252218213157E-01	8.867870E-18
8.1206060299420E-01	5.08E+08	8.1206060299420E-01	6.356645E-18
8.1160878044454E-01	5.84E+08	8.1160878044454E-01	4.556555E-18
8.1116650825402E-01	6.71E+08	8.1116650825402E-01	3.266218E-18
8.1073358455308E-01	7.72E+08	8.1073358455308E-01	2.341283E-18
8.1030981173915E-01	8.88E+08	8.1030981173915E-01	1.678273E-18
8.0989499638636E-01	1.02E+09	8.0989499638636E-01	1.203015E-18

Table D.2. Recommended Characteristic Curves for the Reducing Fill Grout.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.6E-08 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999803697138E-01	5.00E-02	9.9999803697138E-01	6.669260E-01
9.9999544240287E-01	1.00E-01	9.9999544240287E-01	6.196084E-01
9.9998941930292E-01	2.00E-01	9.9998941930292E-01	5.668640E-01
9.9996779497894E-01	5.00E-01	9.9996779497894E-01	4.886646E-01
9.9992529108952E-01	1.00E+00	9.9992529108952E-01	4.233757E-01
9.9982689258689E-01	2.00E+00	9.9982689258689E-01	3.535921E-01
9.9947670468486E-01	5.00E+00	9.9947670468486E-01	2.571604E-01
9.9880207087538E-01	1.00E+01	9.9880207087538E-01	1.848035E-01
9.9730561845921E-01	2.00E+01	9.9730561845921E-01	1.182351E-01
9.9260184433614E-01	5.00E+01	9.9260184433614E-01	5.007098E-02
9.8547612947872E-01	1.00E+02	9.8547612947872E-01	1.975026E-02
9.7462383640950E-01	2.00E+02	9.7462383640950E-01	5.924991E-03
9.5640751468347E-01	5.00E+02	9.5640751468347E-01	8.506385E-04
9.4206489823880E-01	1.00E+03	9.4206489823880E-01	1.663643E-04
9.3926132751510E-01	1.15E+03	9.3926132751510E-01	1.185421E-04
9.3650390531715E-01	1.32E+03	9.3650390531715E-01	8.426938E-05
9.3379725011599E-01	1.52E+03	9.3379725011599E-01	5.978528E-05
9.3114496215600E-01	1.75E+03	9.3114496215600E-01	4.234192E-05
9.2854975661669E-01	2.01E+03	9.2854975661669E-01	2.994381E-05
9.2601358930548E-01	2.31E+03	9.2601358930548E-01	2.114937E-05
9.2353777197667E-01	2.66E+03	9.2353777197667E-01	1.492185E-05
9.2112307584645E-01	3.06E+03	9.2112307584645E-01	1.051846E-05
9.1876982292228E-01	3.52E+03	9.1876982292228E-01	7.408751E-06
9.1647796546741E-01	4.05E+03	9.1647796546741E-01	5.214979E-06
9.1424715435723E-01	4.65E+03	9.1424715435723E-01	3.668749E-06
9.1207679732323E-01	5.35E+03	9.1207679732323E-01	2.579754E-06
9.0996610818267E-01	6.15E+03	9.0996610818267E-01	1.813280E-06
9.0791414816114E-01	7.08E+03	9.0791414816114E-01	1.274103E-06
9.0591986036755E-01	8.14E+03	9.0591986036755E-01	8.949930E-07
9.0398209839876E-01	9.36E+03	9.0398209839876E-01	6.285352E-07
9.0209964995366E-01	1.08E+04	9.0209964995366E-01	4.413171E-07
9.0027125623322E-01	1.24E+04	9.0027125623322E-01	3.098109E-07
8.9849562780241E-01	1.42E+04	8.9849562780241E-01	2.174599E-07
8.9677145749583E-01	1.64E+04	8.9677145749583E-01	1.526188E-07
8.9509743086294E-01	1.88E+04	8.9509743086294E-01	1.071005E-07
8.9347223457321E-01	2.16E+04	8.9347223457321E-01	7.515138E-08
8.9189456313459E-01	2.49E+04	8.9189456313459E-01	5.272905E-08
8.9036312422175E-01	2.86E+04	8.9036312422175E-01	3.699438E-08
8.8887664286103E-01	3.29E+04	8.8887664286103E-01	2.595365E-08
8.8743386467792E-01	3.79E+04	8.8743386467792E-01	1.820714E-08
8.8603355837725E-01	4.35E+04	8.8603355837725E-01	1.277229E-08
8.8467451759729E-01	5.01E+04	8.8467451759729E-01	8.959460E-09

Table D.2. Recommended Characteristic Curves for the Reducing Fill Grout (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.6E-08 cm/s)
8.8335556225407E-01	5.76E+04	8.8335556225407E-01	6.284681E-09
8.8207553947196E-01	6.62E+04	8.8207553947196E-01	4.408337E-09
8.8083332417928E-01	7.61E+04	8.8083332417928E-01	3.092132E-09
8.7962781943396E-01	8.76E+04	8.7962781943396E-01	2.168874E-09
8.7845795653234E-01	1.01E+05	8.7845795653234E-01	1.521264E-09
8.7732269494483E-01	1.16E+05	8.7732269494483E-01	1.067013E-09
8.7622102211391E-01	1.33E+05	8.7622102211391E-01	7.483949E-10
8.7515195314393E-01	1.53E+05	8.7515195314393E-01	5.249142E-10
8.7411453040628E-01	1.76E+05	8.7411453040628E-01	3.681653E-10
8.7310782307939E-01	2.03E+05	8.7310782307939E-01	2.582229E-10
8.7213092663949E-01	2.33E+05	8.7213092663949E-01	1.811109E-10
8.7118296231479E-01	2.68E+05	8.7118296231479E-01	1.270260E-10
8.7026307651360E-01	3.08E+05	8.7026307651360E-01	8.909208E-11
8.6937044023474E-01	3.54E+05	8.6937044023474E-01	6.248623E-11
8.6850424846704E-01	4.07E+05	8.6850424846704E-01	4.382566E-11
8.6766371958349E-01	4.68E+05	8.6766371958349E-01	3.073772E-11
8.6684809473419E-01	5.39E+05	8.6684809473419E-01	2.155828E-11
8.6605663724176E-01	6.20E+05	8.6605663724176E-01	1.512014E-11
8.6528863200194E-01	7.13E+05	8.6528863200194E-01	1.060467E-11
8.6454338489143E-01	8.19E+05	8.6454338489143E-01	7.437686E-12
8.6382022218476E-01	9.42E+05	8.6382022218476E-01	5.216488E-12
8.6311848998144E-01	1.08E+06	8.6311848998144E-01	3.658628E-12
8.6243755364429E-01	1.25E+06	8.6243755364429E-01	2.566008E-12
8.6177679724979E-01	1.43E+06	8.6177679724979E-01	1.799689E-12
8.6113562305080E-01	1.65E+06	8.6113562305080E-01	1.262225E-12
8.6051345095213E-01	1.90E+06	8.6051345095213E-01	8.852706E-13
8.5990971799900E-01	2.18E+06	8.5990971799900E-01	6.208906E-13
8.5932387787858E-01	2.51E+06	8.5932387787858E-01	4.354657E-13
8.5875540043457E-01	2.88E+06	8.5875540043457E-01	3.054167E-13
8.5820377119474E-01	3.31E+06	8.5820377119474E-01	2.142059E-13
8.5766849091137E-01	3.81E+06	8.5766849091137E-01	1.502347E-13
8.5714907511422E-01	4.38E+06	8.5714907511422E-01	1.053680E-13
8.5664505367616E-01	5.04E+06	8.5664505367616E-01	7.390048E-14
8.5615597039088E-01	5.80E+06	8.5615597039088E-01	5.183054E-14
8.5568138256268E-01	6.67E+06	8.5568138256268E-01	3.635166E-14
8.5522086060796E-01	7.67E+06	8.5522086060796E-01	2.549545E-14
8.5477398766816E-01	8.82E+06	8.5477398766816E-01	1.788138E-14
8.5434035923394E-01	1.01E+07	8.5434035923394E-01	1.254121E-14
8.5391958278021E-01	1.17E+07	8.5391958278021E-01	8.795849E-15
8.5351127741177E-01	1.34E+07	8.5351127741177E-01	6.169019E-15
8.5311507351940E-01	1.54E+07	8.5311507351940E-01	4.326677E-15
8.5273061244586E-01	1.77E+07	8.5273061244586E-01	3.034539E-15
8.5235754616183E-01	2.04E+07	8.5235754616183E-01	2.128291E-15

Table D.2. Recommended Characteristic Curves for the Reducing Fill Grout (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.6E-08 cm/s)
8.5199553695128E-01	2.35E+07	8.5199553695128E-01	1.492689E-15
8.5164425710612E-01	2.70E+07	8.5164425710612E-01	1.046906E-15
8.5130338862983E-01	3.10E+07	8.5130338862983E-01	7.342534E-16
8.5097262294986E-01	3.57E+07	8.5097262294986E-01	5.149727E-16
8.5065166063848E-01	4.10E+07	8.5065166063848E-01	3.611790E-16
8.5034021114189E-01	4.72E+07	8.5034021114189E-01	2.533149E-16
8.5003799251733E-01	5.43E+07	8.5003799251733E-01	1.776639E-16
8.4974473117794E-01	6.24E+07	8.4974473117794E-01	1.246055E-16
8.4946016164521E-01	7.18E+07	8.4946016164521E-01	8.739279E-17
8.4918402630871E-01	8.25E+07	8.4918402630871E-01	6.129342E-17
8.4891607519295E-01	9.49E+07	8.4891607519295E-01	4.298849E-17
8.4865606573113E-01	1.09E+08	8.4865606573113E-01	3.015021E-17
8.4840376254558E-01	1.25E+08	8.4840376254558E-01	2.114602E-17
8.4815893723475E-01	1.44E+08	8.4815893723475E-01	1.483088E-17
8.4792136816646E-01	1.66E+08	8.4792136816646E-01	1.040172E-17
8.4769084027725E-01	1.91E+08	8.4769084027725E-01	7.295305E-18
8.4746714487777E-01	2.19E+08	8.4746714487777E-01	5.116603E-18
8.4725007946381E-01	2.52E+08	8.4725007946381E-01	3.588558E-18
8.4703944753305E-01	2.90E+08	8.4703944753305E-01	2.516855E-18
8.4683505840714E-01	3.34E+08	8.4683505840714E-01	1.765211E-18
8.4663672705912E-01	3.84E+08	8.4663672705912E-01	1.238040E-18
8.4644427394591E-01	4.41E+08	8.4644427394591E-01	8.683064E-19
8.4625752484580E-01	5.08E+08	8.4625752484580E-01	6.089916E-19
8.4607631070070E-01	5.84E+08	8.4607631070070E-01	4.271196E-19
8.4590046746315E-01	6.71E+08	8.4590046746315E-01	2.995628E-19
8.4572983594780E-01	7.72E+08	8.4572983594780E-01	2.101000E-19
8.4556426168726E-01	8.88E+08	8.4556426168726E-01	1.473548E-19
8.4540359479235E-01	1.02E+09	8.4540359479235E-01	1.033481E-19

Table D.3. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1A.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.9E-09 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9998843163594E-01	5.00E-02	9.9998843163594E-01	5.174265E-01
9.9997402602850E-01	1.00E-01	9.9997402602850E-01	4.690570E-01
9.9994168891913E-01	2.00E-01	9.9994168891913E-01	4.175887E-01
9.9983024469787E-01	5.00E-01	9.9983024469787E-01	3.454597E-01
9.9961937164427E-01	1.00E+00	9.9961937164427E-01	2.886782E-01
9.9914808334649E-01	2.00E+00	9.9914808334649E-01	2.312062E-01
9.9754541079279E-01	5.00E+00	9.9754541079279E-01	1.571669E-01
9.9460049612919E-01	1.00E+01	9.9460049612919E-01	1.059682E-01
9.8839770626823E-01	2.00E+01	9.8839770626823E-01	6.275097E-02
9.7041230748223E-01	5.00E+01	9.7041230748223E-01	2.359991E-02
9.4553616118114E-01	1.00E+02	9.4553616118114E-01	8.571866E-03
9.1048543440806E-01	2.00E+02	9.1048543440806E-01	2.452704E-03
8.5485983898169E-01	5.00E+02	8.5485983898169E-01	3.561730E-04
8.1165617526879E-01	1.00E+03	8.1165617526879E-01	7.328666E-05
8.0316225535349E-01	1.15E+03	8.0316225535349E-01	5.289865E-05
7.9477856489010E-01	1.32E+03	7.9477856489010E-01	3.811728E-05
7.8651585973235E-01	1.52E+03	7.8651585973235E-01	2.742581E-05
7.7838274266446E-01	1.75E+03	7.7838274266446E-01	1.970819E-05
7.7038594031742E-01	2.01E+03	7.7038594031742E-01	1.414692E-05
7.6253056033279E-01	2.31E+03	7.6253056033279E-01	1.014546E-05
7.5482032525865E-01	2.66E+03	7.5482032525865E-01	7.270013E-06
7.4725778181594E-01	3.06E+03	7.4725778181594E-01	5.205975E-06
7.3984448567128E-01	3.52E+03	7.3984448567128E-01	3.725767E-06
7.3258116283320E-01	4.05E+03	7.3258116283320E-01	2.665098E-06
7.2546784937816E-01	4.65E+03	7.2546784937816E-01	1.905576E-06
7.1850401151760E-01	5.35E+03	7.1850401151760E-01	1.362016E-06
7.1168864812421E-01	6.15E+03	7.1168864812421E-01	9.732048E-07
7.0502037780908E-01	7.08E+03	7.0502037780908E-01	6.952039E-07
6.9849751253321E-01	8.14E+03	6.9849751253321E-01	4.965043E-07
6.9211811958022E-01	9.36E+03	6.9211811958022E-01	3.545286E-07
6.8588007353826E-01	1.08E+04	6.8588007353826E-01	2.531099E-07
6.7978109975467E-01	1.24E+04	6.7978109975467E-01	1.806788E-07
6.7381881054673E-01	1.42E+04	6.7381881054673E-01	1.289598E-07
6.6799073528317E-01	1.64E+04	6.6799073528317E-01	9.203616E-08
6.6229434529712E-01	1.88E+04	6.6229434529712E-01	6.567888E-08
6.5672707445296E-01	2.16E+04	6.5672707445296E-01	4.686641E-08
6.5128633606777E-01	2.49E+04	6.5128633606777E-01	3.344037E-08
6.4596953678176E-01	2.86E+04	6.4596953678176E-01	2.385931E-08
6.4077408787985E-01	3.29E+04	6.4077408787985E-01	1.702259E-08
6.3569741448785E-01	3.79E+04	6.3569741448785E-01	1.214442E-08
6.3073696299888E-01	4.35E+04	6.3073696299888E-01	8.663919E-09
6.2589020702852E-01	5.01E+04	6.2589020702852E-01	6.180734E-09

Table D.3. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1A (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.9E-09 cm/s)
6.2115465214861E-01	5.76E+04	6.2115465214861E-01	4.409159E-09
6.1652783960858E-01	6.62E+04	6.1652783960858E-01	3.145306E-09
6.1200734921862E-01	7.61E+04	6.1200734921862E-01	2.243690E-09
6.0759080154037E-01	8.76E+04	6.0759080154037E-01	1.600504E-09
6.0327585950612E-01	1.01E+05	6.0327585950612E-01	1.141683E-09
5.9906022956745E-01	1.16E+05	5.9906022956745E-01	8.143846E-10
5.9494166245727E-01	1.33E+05	5.9494166245727E-01	5.809115E-10
5.9091795363493E-01	1.53E+05	5.9091795363493E-01	4.143690E-10
5.8698694347227E-01	1.76E+05	5.8698694347227E-01	2.955709E-10
5.8314651722883E-01	2.03E+05	5.8314651722883E-01	2.108307E-10
5.7939460485584E-01	2.33E+05	5.7939460485584E-01	1.503849E-10
5.7572918066226E-01	2.68E+05	5.7572918066226E-01	1.072686E-10
5.7214826287006E-01	3.08E+05	5.7214826287006E-01	7.651382E-11
5.6864991308150E-01	3.54E+05	5.6864991308150E-01	5.457652E-11
5.6523223567700E-01	4.07E+05	5.6523223567700E-01	3.892878E-11
5.6189337715919E-01	4.68E+05	5.6189337715919E-01	2.776738E-11
5.5863152545579E-01	5.39E+05	5.5863152545579E-01	1.980607E-11
5.5544490919189E-01	6.20E+05	5.5544490919189E-01	1.412736E-11
5.5233179694023E-01	7.13E+05	5.5233179694023E-01	1.007681E-11
5.4929049645657E-01	8.19E+05	5.4929049645657E-01	7.187616E-12
5.4631935390608E-01	9.42E+05	5.4631935390608E-01	5.126798E-12
5.4341675308528E-01	1.08E+06	5.4341675308528E-01	3.656850E-12
5.4058111464361E-01	1.25E+06	5.4058111464361E-01	2.608362E-12
5.3781089530767E-01	1.43E+06	5.3781089530767E-01	1.860495E-12
5.3510458711068E-01	1.65E+06	5.3510458711068E-01	1.327054E-12
5.3246071662917E-01	1.90E+06	5.3246071662917E-01	9.465616E-13
5.2987784422856E-01	2.18E+06	5.2987784422856E-01	6.751634E-13
5.2735456331894E-01	2.51E+06	5.2735456331894E-01	4.815803E-13
5.2488949962196E-01	2.88E+06	5.2488949962196E-01	3.435014E-13
5.2248131044964E-01	3.31E+06	5.2248131044964E-01	2.450125E-13
5.2012868399570E-01	3.81E+06	5.2012868399570E-01	1.747623E-13
5.1783033863981E-01	4.38E+06	5.1783033863981E-01	1.246543E-13
5.1558502226500E-01	5.04E+06	5.1558502226500E-01	8.891332E-14
5.1339151158849E-01	5.80E+06	5.1339151158849E-01	6.342000E-14
5.1124861150597E-01	6.67E+06	5.1124861150597E-01	4.523615E-14
5.0915515444940E-01	7.67E+06	5.0915515444940E-01	3.226599E-14
5.0710999975824E-01	8.82E+06	5.0710999975824E-01	2.301465E-14
5.0511203306410E-01	1.01E+07	5.0511203306410E-01	1.641586E-14
5.0316016568864E-01	1.17E+07	5.0316016568864E-01	1.170908E-14
5.0125333405460E-01	1.34E+07	5.0125333405460E-01	8.351841E-15
4.9939049910975E-01	1.54E+07	4.9939049910975E-01	5.957190E-15
4.9757064576359E-01	1.77E+07	4.9757064576359E-01	4.249137E-15
4.9579278233671E-01	2.04E+07	4.9579278233671E-01	3.030819E-15

Table D.3. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1A (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.9E-09 cm/s)
4.9405594002231E-01	2.35E+07	4.9405594002231E-01	2.161818E-15
4.9235917236003E-01	2.70E+07	4.9235917236003E-01	1.541979E-15
4.9070155472150E-01	3.10E+07	4.9070155472150E-01	1.099861E-15
4.8908218380768E-01	3.57E+07	4.8908218380768E-01	7.845070E-16
4.8750017715752E-01	4.10E+07	4.8750017715752E-01	5.595721E-16
4.8595467266792E-01	4.72E+07	4.8595467266792E-01	3.991308E-16
4.8444482812455E-01	5.43E+07	4.8444482812455E-01	2.846915E-16
4.8296982074342E-01	6.24E+07	4.8296982074342E-01	2.030643E-16
4.8152884672301E-01	7.18E+07	4.8152884672301E-01	1.448414E-16
4.8012112080658E-01	8.25E+07	4.8012112080658E-01	1.033123E-16
4.7874587585456E-01	9.49E+07	4.7874587585456E-01	7.369045E-17
4.7740236242676E-01	1.09E+08	4.7740236242676E-01	5.256182E-17
4.7608984837418E-01	1.25E+08	4.7608984837418E-01	3.749122E-17
4.7480761844020E-01	1.44E+08	4.7480761844020E-01	2.674168E-17
4.7355497387093E-01	1.66E+08	4.7355497387093E-01	1.907427E-17
4.7233123203458E-01	1.91E+08	4.7233123203458E-01	1.360527E-17
4.7113572604954E-01	2.19E+08	4.7113572604954E-01	9.704347E-18
4.6996780442103E-01	2.52E+08	4.6996780442103E-01	6.921903E-18
4.6882683068618E-01	2.90E+08	4.6882683068618E-01	4.937245E-18
4.6771218306719E-01	3.34E+08	4.6771218306719E-01	3.521631E-18
4.6662325413259E-01	3.84E+08	4.6662325413259E-01	2.511904E-18
4.6555945046621E-01	4.41E+08	4.6555945046621E-01	1.791687E-18
4.6452019234387E-01	5.08E+08	4.6452019234387E-01	1.277972E-18
4.6350491341746E-01	5.84E+08	4.6350491341746E-01	9.115502E-19
4.6251306040633E-01	6.71E+08	4.6251306040633E-01	6.501892E-19
4.6154409279583E-01	7.72E+08	4.6154409279583E-01	4.637660E-19
4.6059748254271E-01	8.88E+08	4.6059748254271E-01	3.307944E-19
4.5967271378742E-01	1.02E+09	4.5967271378742E-01	2.359486E-19

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1B.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.3E-08 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999158264902E-01	5.00E-02	9.9999158264902E-01	7.255412E-01
9.9997976425553E-01	1.00E-01	9.9997976425553E-01	6.754006E-01
9.9995135872628E-01	2.00E-01	9.9995135872628E-01	6.175069E-01
9.9984502276693E-01	5.00E-01	9.9984502276693E-01	5.282903E-01
9.9962804230954E-01	1.00E+00	9.9962804230954E-01	4.512312E-01
9.9910944552563E-01	2.00E+00	9.9910944552563E-01	3.669776E-01
9.9720374212636E-01	5.00E+00	9.9720374212636E-01	2.493464E-01
9.9347975633387E-01	1.00E+01	9.9347975633387E-01	1.630205E-01
9.8536281847174E-01	2.00E+01	9.8536281847174E-01	8.929981E-02
9.6219974794603E-01	5.00E+01	9.6219974794603E-01	2.722709E-02
9.3292019244093E-01	1.00E+02	9.3292019244093E-01	7.809633E-03
8.9676391608424E-01	2.00E+02	8.9676391608424E-01	1.723658E-03
8.4792137564475E-01	5.00E+02	8.4792137564475E-01	1.824502E-04
8.1482572545491E-01	1.00E+03	8.1482572545491E-01	3.046548E-05
8.0870126415132E-01	1.15E+03	8.0870126415132E-01	2.113539E-05
8.0276665644505E-01	1.32E+03	8.0276665644505E-01	1.464711E-05
7.9702114792107E-01	1.52E+03	7.9702114792107E-01	1.014157E-05
7.9146290494081E-01	1.75E+03	7.9146290494081E-01	7.016656E-06
7.8608924198265E-01	2.01E+03	7.8608924198265E-01	4.851536E-06
7.8089681223056E-01	2.31E+03	7.8089681223056E-01	3.352709E-06
7.7588176589374E-01	2.66E+03	7.7588176589374E-01	2.315885E-06
7.7103988065808E-01	3.06E+03	7.7103988065808E-01	1.599094E-06
7.6636666838299E-01	3.52E+03	7.6636666838299E-01	1.103806E-06
7.6185746176127E-01	4.05E+03	7.6185746176127E-01	7.617208E-07
7.5750748422271E-01	4.65E+03	7.5750748422271E-01	5.255348E-07
7.5331190592437E-01	5.35E+03	7.5331190592437E-01	3.625146E-07
7.4926588825756E-01	6.15E+03	7.4926588825756E-01	2.500236E-07
7.4536461892628E-01	7.08E+03	7.4536461892628E-01	1.724166E-07
7.4160333931921E-01	8.14E+03	7.4160333931921E-01	1.188855E-07
7.3797736560886E-01	9.36E+03	7.3797736560886E-01	8.196690E-08
7.3448210476440E-01	1.08E+04	7.3448210476440E-01	5.650854E-08
7.3111306645540E-01	1.24E+04	7.3111306645540E-01	3.895483E-08
7.2786587164833E-01	1.42E+04	7.2786587164833E-01	2.685250E-08
7.2473625855159E-01	1.64E+04	7.2473625855159E-01	1.850922E-08
7.2172008644355E-01	1.88E+04	7.2172008644355E-01	1.275777E-08
7.1881333781834E-01	2.16E+04	7.1881333781834E-01	8.793212E-09
7.1601211920226E-01	2.49E+04	7.1601211920226E-01	6.060500E-09
7.1331266092634E-01	2.86E+04	7.1331266092634E-01	4.176953E-09
7.1071131608567E-01	3.29E+04	7.1071131608567E-01	2.878740E-09
7.0820455887192E-01	3.79E+04	7.0820455887192E-01	1.983985E-09
7.0578898242839E-01	4.35E+04	7.0578898242839E-01	1.367315E-09
7.0346129634811E-01	5.01E+04	7.0346129634811E-01	9.423100E-10

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1B (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.3E-08 cm/s)
7.0121832391119E-01	5.76E+04	7.0121832391119E-01	6.494041E-10
6.9905699913824E-01	6.62E+04	6.9905699913824E-01	4.475410E-10
6.9697436372138E-01	7.61E+04	6.9697436372138E-01	3.084237E-10
6.9496756388109E-01	8.76E+04	6.9496756388109E-01	2.125496E-10
6.9303384718759E-01	1.01E+05	6.9303384718759E-01	1.464775E-10
6.9117055937671E-01	1.16E+05	6.9117055937671E-01	1.009438E-10
6.8937514118381E-01	1.33E+05	6.8937514118381E-01	6.956444E-11
6.8764512521396E-01	1.53E+05	6.8764512521396E-01	4.793951E-11
6.8597813286220E-01	1.76E+05	6.8597813286220E-01	3.303687E-11
6.8437187129450E-01	2.03E+05	6.8437187129450E-01	2.276687E-11
6.8282413049698E-01	2.33E+05	6.8282413049698E-01	1.568943E-11
6.8133278039900E-01	2.68E+05	6.8133278039900E-01	1.081211E-11
6.7989576807395E-01	3.08E+05	6.7989576807395E-01	7.450974E-12
6.7851111502006E-01	3.54E+05	6.7851111502006E-01	5.134703E-12
6.7717691452256E-01	4.07E+05	6.7717691452256E-01	3.538485E-12
6.7589132909774E-01	4.68E+05	6.7589132909774E-01	2.438479E-12
6.7465258801846E-01	5.39E+05	6.7465258801846E-01	1.680430E-12
6.7345898492065E-01	6.20E+05	6.7345898492065E-01	1.158035E-12
6.7230887548939E-01	7.13E+05	6.7230887548939E-01	7.980364E-13
6.7120067522328E-01	8.19E+05	6.7120067522328E-01	5.499505E-13
6.7013285727538E-01	9.42E+05	6.7013285727538E-01	3.789871E-13
6.6910395036881E-01	1.08E+06	6.6910395036881E-01	2.611711E-13
6.6811253678514E-01	1.25E+06	6.6811253678514E-01	1.799806E-13
6.6715725042355E-01	1.43E+06	6.6715725042355E-01	1.240299E-13
6.6623677492851E-01	1.65E+06	6.6623677492851E-01	8.547258E-14
6.6534984188414E-01	1.90E+06	6.6534984188414E-01	5.890162E-14
6.6449522907287E-01	2.18E+06	6.6449522907287E-01	4.059081E-14
6.6367175879664E-01	2.51E+06	6.6367175879664E-01	2.797229E-14
6.6287829625815E-01	2.88E+06	6.6287829625815E-01	1.927651E-14
6.6211374800064E-01	3.31E+06	6.6211374800064E-01	1.328400E-14
6.6137706040374E-01	3.81E+06	6.6137706040374E-01	9.154382E-15
6.6066721823379E-01	4.38E+06	6.6066721823379E-01	6.308546E-15
6.5998324324655E-01	5.04E+06	6.5998324324655E-01	4.347400E-15
6.5932419284058E-01	5.80E+06	6.5932419284058E-01	2.995917E-15
6.5868915875936E-01	6.67E+06	6.5868915875936E-01	2.064572E-15
6.5807726584060E-01	7.67E+06	6.5807726584060E-01	1.422756E-15
6.5748767081094E-01	8.82E+06	6.5748767081094E-01	9.804615E-16
6.5691956112436E-01	1.01E+07	6.5691956112436E-01	6.756640E-16
6.5637215384296E-01	1.17E+07	6.5637215384296E-01	4.656193E-16
6.5584469455834E-01	1.34E+07	6.5584469455834E-01	3.208715E-16
6.5533645635221E-01	1.54E+07	6.5533645635221E-01	2.211217E-16
6.5484673879492E-01	1.77E+07	6.5484673879492E-01	1.523813E-16
6.5437486698031E-01	2.04E+07	6.5437486698031E-01	1.050103E-16

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 1B (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.3E-08 cm/s)
6.5392019059581E-01	2.35E+07	6.5392019059581E-01	7.236558E-17
6.5348208302632E-01	2.70E+07	6.5348208302632E-01	4.986918E-17
6.5305994049077E-01	3.10E+07	6.5305994049077E-01	3.436627E-17
6.5265318121006E-01	3.57E+07	6.5265318121006E-01	2.368278E-17
6.5226124460544E-01	4.10E+07	6.5226124460544E-01	1.632048E-17
6.5188359052590E-01	4.72E+07	6.5188359052590E-01	1.124691E-17
6.5151969850389E-01	5.43E+07	6.5151969850389E-01	7.750563E-18
6.5116906703800E-01	6.24E+07	6.5116906703800E-01	5.341134E-18
6.5083121290190E-01	7.18E+07	6.5083121290190E-01	3.680727E-18
6.5050567047837E-01	8.25E+07	6.5050567047837E-01	2.536494E-18
6.5019199111764E-01	9.49E+07	6.5019199111764E-01	1.747970E-18
6.4988974251909E-01	1.09E+08	6.4988974251909E-01	1.204576E-18
6.4959850813547E-01	1.25E+08	6.4959850813547E-01	8.301076E-19
6.4931788659887E-01	1.44E+08	6.4931788659887E-01	5.720508E-19
6.4904749116755E-01	1.66E+08	6.4904749116755E-01	3.942165E-19
6.4878694919297E-01	1.91E+08	6.4878694919297E-01	2.716658E-19
6.4853590160623E-01	2.19E+08	6.4853590160623E-01	1.872127E-19
6.4829400242321E-01	2.52E+08	6.4829400242321E-01	1.290136E-19
6.4806091826776E-01	2.90E+08	6.4806091826776E-01	8.890693E-20
6.4783632791224E-01	3.34E+08	6.4783632791224E-01	6.126830E-20
6.4761992183483E-01	3.84E+08	6.4761992183483E-01	4.222172E-20
6.4741140179299E-01	4.41E+08	6.4741140179299E-01	2.909620E-20
6.4721048041236E-01	5.08E+08	6.4721048041236E-01	2.005102E-20
6.4701688079080E-01	5.84E+08	6.4701688079080E-01	1.381773E-20
6.4683033611672E-01	6.71E+08	6.4683033611672E-01	9.522184E-21
6.4665058930137E-01	7.72E+08	6.4665058930137E-01	6.562010E-21
6.4647739262458E-01	8.88E+08	6.4647739262458E-01	4.522070E-21
6.4631050739329E-01	1.02E+09	6.4631050739329E-01	3.116288E-21

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 2.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.6E-09 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999456409664E-01	5.00E-02	9.9999456409664E-01	5.978787E-01
9.9998744318343E-01	1.00E-01	9.9998744318343E-01	5.447128E-01
9.9997099932177E-01	2.00E-01	9.9997099932177E-01	4.863940E-01
9.9991236992326E-01	5.00E-01	9.9991236992326E-01	4.018814E-01
9.9979800131291E-01	1.00E+00	9.9979800131291E-01	3.333328E-01
9.9953571869007E-01	2.00E+00	9.9953571869007E-01	2.625164E-01
9.9862064277240E-01	5.00E+00	9.9862064277240E-01	1.702697E-01
9.9691993814534E-01	1.00E+01	9.9691993814534E-01	1.073659E-01
9.9338354876193E-01	2.00E+01	9.9338354876193E-01	5.700609E-02
9.8380111315060E-01	5.00E+01	9.8380111315060E-01	1.716452E-02
9.7204879141839E-01	1.00E+02	9.7204879141839E-01	5.074477E-03
9.5753541084825E-01	2.00E+02	9.5753541084825E-01	1.195643E-03
9.3738589274499E-01	5.00E+02	9.3738589274499E-01	1.423886E-04
9.2315285979779E-01	1.00E+03	9.2315285979779E-01	2.622710E-05
9.2045464589848E-01	1.15E+03	9.2045464589848E-01	1.856429E-05
9.1781875360022E-01	1.32E+03	9.1781875360022E-01	1.312702E-05
9.1524597174004E-01	1.52E+03	9.1524597174004E-01	9.274273E-06
9.1273664028139E-01	1.75E+03	9.1273664028139E-01	6.547493E-06
9.1029072907951E-01	2.01E+03	9.1029072907951E-01	4.619550E-06
9.0790790564003E-01	2.31E+03	9.0790790564003E-01	3.257578E-06
9.0558759288389E-01	2.66E+03	9.0558759288389E-01	2.296124E-06
9.0332901801638E-01	3.06E+03	9.0332901801638E-01	1.617822E-06
9.0113125359806E-01	3.52E+03	9.0113125359806E-01	1.139532E-06
8.9899325186212E-01	4.05E+03	8.9899325186212E-01	8.024241E-07
8.9691387323965E-01	4.65E+03	8.9691387323965E-01	5.649125E-07
8.9489190995664E-01	5.35E+03	8.9489190995664E-01	3.976250E-07
8.9292610546498E-01	6.15E+03	8.9292610546498E-01	2.798301E-07
8.9101517037100E-01	7.08E+03	8.9101517037100E-01	1.969040E-07
8.8915779543299E-01	8.14E+03	8.8915779543299E-01	1.385363E-07
8.8735266211518E-01	9.36E+03	8.8735266211518E-01	9.746058E-08
8.8559845111183E-01	1.08E+04	8.8559845111183E-01	6.855796E-08
8.8389384918983E-01	1.24E+04	8.8389384918983E-01	4.822318E-08
8.8223755464220E-01	1.42E+04	8.8223755464220E-01	3.391780E-08
8.8062828159685E-01	1.64E+04	8.8062828159685E-01	2.385489E-08
8.7906476338416E-01	1.88E+04	8.7906476338416E-01	1.677677E-08
8.7754575513251E-01	2.16E+04	8.7754575513251E-01	1.179841E-08
8.7607003573196E-01	2.49E+04	8.7607003573196E-01	8.297082E-09
8.7463640928187E-01	2.86E+04	8.7463640928187E-01	5.834666E-09
8.7324370611851E-01	3.29E+04	8.7324370611851E-01	4.102958E-09
8.7189078350128E-01	3.79E+04	8.7189078350128E-01	2.885161E-09
8.7057652602282E-01	4.35E+04	8.7057652602282E-01	2.028787E-09
8.6929984579627E-01	5.01E+04	8.6929984579627E-01	1.426582E-09

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 2 (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.6E-09 cm/s)
8.6805968246373E-01	5.76E+04	8.6805968246373E-01	1.003119E-09
8.6685500306186E-01	6.62E+04	8.6685500306186E-01	7.053491E-10
8.6568480177416E-01	7.61E+04	8.6568480177416E-01	4.959664E-10
8.6454809959419E-01	8.76E+04	8.6454809959419E-01	3.487365E-10
8.6344394391927E-01	1.01E+05	8.6344394391927E-01	2.452111E-10
8.6237140809100E-01	1.16E+05	8.6237140809100E-01	1.724173E-10
8.6132959089566E-01	1.33E+05	8.6132959089566E-01	1.212327E-10
8.6031761603511E-01	1.53E+05	8.6031761603511E-01	8.524267E-11
8.5933463157702E-01	1.76E+05	8.5933463157702E-01	5.993675E-11
8.5837980939131E-01	2.03E+05	8.5837980939131E-01	4.214327E-11
8.5745234457860E-01	2.33E+05	8.5745234457860E-01	2.963210E-11
8.5655145489513E-01	2.68E+05	8.5655145489513E-01	2.083511E-11
8.5567638017794E-01	3.08E+05	8.5567638017794E-01	1.464970E-11
8.5482638177307E-01	3.54E+05	8.5482638177307E-01	1.030056E-11
8.5400074196922E-01	4.07E+05	8.5400074196922E-01	7.242569E-12
8.5319876343869E-01	4.68E+05	8.5319876343869E-01	5.092418E-12
8.5241976868682E-01	5.39E+05	8.5241976868682E-01	3.580594E-12
8.5166309951128E-01	6.20E+05	8.5166309951128E-01	2.517595E-12
8.5092811647181E-01	7.13E+05	8.5092811647181E-01	1.770176E-12
8.5021419837111E-01	8.19E+05	8.5021419837111E-01	1.244649E-12
8.4952074174725E-01	9.42E+05	8.4952074174725E-01	8.751390E-13
8.4884716037786E-01	1.08E+06	8.4884716037786E-01	6.153286E-13
8.4819288479632E-01	1.25E+06	8.4819288479632E-01	4.326503E-13
8.4755736181992E-01	1.43E+06	8.4755736181992E-01	3.042054E-13
8.4694005409009E-01	1.65E+06	8.4694005409009E-01	2.138930E-13
8.4634043962448E-01	1.90E+06	8.4634043962448E-01	1.503926E-13
8.4575801138092E-01	2.18E+06	8.4575801138092E-01	1.057441E-13
8.4519227683304E-01	2.51E+06	8.4519227683304E-01	7.435079E-14
8.4464275755731E-01	2.88E+06	8.4464275755731E-01	5.227753E-14
8.4410898883142E-01	3.31E+06	8.4410898883142E-01	3.675738E-14
8.4359051924367E-01	3.81E+06	8.4359051924367E-01	2.584485E-14
8.4308691031319E-01	4.38E+06	8.4308691031319E-01	1.817203E-14
8.4259773612070E-01	5.04E+06	8.4259773612070E-01	1.277712E-14
8.4212258294967E-01	5.80E+06	8.4212258294967E-01	8.983847E-15
8.4166104893750E-01	6.67E+06	8.4166104893750E-01	6.316721E-15
8.4121274373649E-01	7.67E+06	8.4121274373649E-01	4.441412E-15
8.4077728818452E-01	8.82E+06	8.4077728818452E-01	3.122845E-15
8.4035431398491E-01	1.01E+07	8.4035431398491E-01	2.195734E-15
8.3994346339542E-01	1.17E+07	8.3994346339542E-01	1.543864E-15
8.3954438892611E-01	1.34E+07	8.3954438892611E-01	1.085522E-15
8.3915675304577E-01	1.54E+07	8.3915675304577E-01	7.632518E-16
8.3878022789669E-01	1.77E+07	8.3878022789669E-01	5.366574E-16
8.3841449501761E-01	2.04E+07	8.3841449501761E-01	3.773345E-16

Table D.4. Recommended Characteristic Curves for Alternative Reducing Fill Grout 2 (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.6E-09 cm/s)
8.3805924507454E-01	2.35E+07	8.3805924507454E-01	2.653113E-16
8.3771417759929E-01	2.70E+07	8.3771417759929E-01	1.865456E-16
8.3737900073544E-01	3.10E+07	8.3737900073544E-01	1.311639E-16
8.3705343099162E-01	3.57E+07	8.3705343099162E-01	9.222396E-17
8.3673719300179E-01	4.10E+07	8.3673719300179E-01	6.484449E-17
8.3643001929241E-01	4.72E+07	8.3643001929241E-01	4.559344E-17
8.3613165005628E-01	5.43E+07	8.3613165005628E-01	3.205765E-17
8.3584183293284E-01	6.24E+07	8.3584183293284E-01	2.254037E-17
8.3556032279473E-01	7.18E+07	8.3556032279473E-01	1.584858E-17
8.3528688154056E-01	8.25E+07	8.3528688154056E-01	1.114345E-17
8.3502127789346E-01	9.49E+07	8.3502127789346E-01	7.835179E-18
8.3476328720556E-01	1.09E+08	8.3476328720556E-01	5.509069E-18
8.3451269126798E-01	1.25E+08	8.3451269126798E-01	3.873535E-18
8.3426927812624E-01	1.44E+08	8.3426927812624E-01	2.723559E-18
8.3403284190107E-01	1.66E+08	8.3403284190107E-01	1.914988E-18
8.3380318261424E-01	1.91E+08	8.3380318261424E-01	1.346466E-18
8.3358010601943E-01	2.19E+08	8.3358010601943E-01	9.467269E-19
8.3336342343796E-01	2.52E+08	8.3336342343796E-01	6.656624E-19
8.3315295159921E-01	2.90E+08	8.3315295159921E-01	4.680404E-19
8.3294851248557E-01	3.34E+08	8.3294851248557E-01	3.290884E-19
8.3274993318194E-01	3.84E+08	8.3274993318194E-01	2.313886E-19
8.3255704572944E-01	4.41E+08	8.3255704572944E-01	1.626939E-19
8.3236968698337E-01	5.08E+08	8.3236968698337E-01	1.143933E-19
8.3218769847521E-01	5.84E+08	8.3218769847521E-01	8.043219E-20
8.3201092627858E-01	6.71E+08	8.3201092627858E-01	5.655346E-20
8.3183922087910E-01	7.72E+08	8.3183922087910E-01	3.976386E-20
8.3167243704787E-01	8.88E+08	8.3167243704787E-01	2.795875E-20
8.3151043371867E-01	1.02E+09	8.3151043371867E-01	1.965835E-20

Table D.5. Recommended Characteristic Curves for the Base Mat Surrogate.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.5E-08 cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9998338807784E-01	5.00E-02	9.9998338807784E-01	6.413759E-01
9.9996137980028E-01	1.00E-01	9.9996137980028E-01	5.905842E-01
9.9991022488774E-01	2.00E-01	9.9991022488774E-01	5.341789E-01
9.9972633405279E-01	5.00E-01	9.9972633405279E-01	4.510947E-01
9.9936467630313E-01	1.00E+00	9.9936467630313E-01	3.823999E-01
9.9852802708792E-01	2.00E+00	9.9852802708792E-01	3.099342E-01
9.9556535327948E-01	5.00E+00	9.9556535327948E-01	2.123163E-01
9.8993414531007E-01	1.00E+01	9.8993414531007E-01	1.422723E-01
9.7780138769010E-01	2.00E+01	9.7780138769010E-01	8.215088E-02
9.4244990780599E-01	5.00E+01	9.4244990780599E-01	2.853688E-02
8.9490307640768E-01	1.00E+02	8.9490307640768E-01	9.391429E-03
8.3131284591558E-01	2.00E+02	8.3131284591558E-01	2.389848E-03
7.3741316925452E-01	5.00E+02	7.3741316925452E-01	2.978810E-04
6.6911476863451E-01	1.00E+03	6.6911476863451E-01	5.519762E-05
6.5608592588432E-01	1.15E+03	6.5608592588432E-01	3.905019E-05
6.4334535752348E-01	1.32E+03	6.4334535752348E-01	2.758734E-05
6.3090172188359E-01	1.52E+03	6.3090172188359E-01	1.946576E-05
6.1876061834088E-01	1.75E+03	6.1876061834088E-01	1.372099E-05
6.0692508834663E-01	2.01E+03	6.0692508834663E-01	9.663164E-06
5.9539605537738E-01	2.31E+03	5.9539605537738E-01	6.800334E-06
5.8417270619246E-01	2.66E+03	5.8417270619246E-01	4.782634E-06
5.7325281765808E-01	3.06E+03	5.7325281765808E-01	3.361800E-06
5.6263303437234E-01	3.52E+03	5.6263303437234E-01	2.362000E-06
5.5230910267801E-01	4.05E+03	5.5230910267801E-01	1.658905E-06
5.4227606659464E-01	4.65E+03	5.4227606659464E-01	1.164722E-06
5.3252843089484E-01	5.35E+03	5.3252843089484E-01	8.175301E-07
5.2306029610411E-01	6.15E+03	5.2306029610411E-01	5.736997E-07
5.1386546969592E-01	7.08E+03	5.1386546969592E-01	4.025135E-07
5.0493755723421E-01	8.14E+03	5.0493755723421E-01	2.823608E-07
4.9627003671519E-01	9.36E+03	4.9627003671519E-01	1.980468E-07
4.8785631889720E-01	1.08E+04	4.8785631889720E-01	1.388928E-07
4.7968979599052E-01	1.24E+04	4.7968979599052E-01	9.739766E-08
4.7176388071010E-01	1.42E+04	4.7176388071010E-01	6.829371E-08
4.6407203737425E-01	1.64E+04	4.6407203737425E-01	4.788308E-08
4.5660780645596E-01	1.88E+04	4.5660780645596E-01	3.357047E-08
4.4936482375917E-01	2.16E+04	4.4936482375917E-01	2.353481E-08
4.4233683519293E-01	2.49E+04	4.4233683519293E-01	1.649854E-08
4.3551770794950E-01	2.86E+04	4.3551770794950E-01	1.156551E-08
4.2890143875215E-01	3.29E+04	4.2890143875215E-01	8.107198E-09
4.2248215972177E-01	3.79E+04	4.2248215972177E-01	5.682843E-09
4.1625414231416E-01	4.35E+04	4.1625414231416E-01	3.983374E-09
4.1021179969950E-01	5.01E+04	4.1021179969950E-01	2.792085E-09

Table D.5. Recommended Characteristic Curves for the Base Mat Surrogate (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.5E-08 cm/s)
4.0434968788879E-01	5.76E+04	4.0434968788879E-01	1.957039E-09
3.9866250585715E-01	6.62E+04	3.9866250585715E-01	1.371718E-09
3.9314509486847E-01	7.61E+04	3.9314509486847E-01	9.614465E-10
3.8779243716861E-01	8.76E+04	3.8779243716861E-01	6.738784E-10
3.8259965418366E-01	1.01E+05	3.8259965418366E-01	4.723181E-10
3.7756200433448E-01	1.16E+05	3.7756200433448E-01	3.310433E-10
3.7267488055831E-01	1.33E+05	3.7267488055831E-01	2.320238E-10
3.6793380761081E-01	1.53E+05	3.6793380761081E-01	1.626216E-10
3.6333443920848E-01	1.76E+05	3.6333443920848E-01	1.139783E-10
3.5887255505966E-01	2.03E+05	3.5887255505966E-01	7.988493E-11
3.5454405782314E-01	2.33E+05	3.5454405782314E-01	5.598945E-11
3.5034497002588E-01	2.68E+05	3.5034497002588E-01	3.924159E-11
3.4627143096474E-01	3.08E+05	3.4627143096474E-01	2.750338E-11
3.4231969361264E-01	3.54E+05	3.4231969361264E-01	1.927635E-11
3.3848612154476E-01	4.07E+05	3.3848612154476E-01	1.351023E-11
3.3476718589743E-01	4.68E+05	3.3476718589743E-01	9.468919E-12
3.3115946236960E-01	5.39E+05	3.3115946236960E-01	6.636477E-12
3.2765962827417E-01	6.20E+05	3.2765962827417E-01	4.651300E-12
3.2426445964518E-01	7.13E+05	3.2426445964518E-01	3.259949E-12
3.2097082840477E-01	8.19E+05	3.2097082840477E-01	2.284794E-12
3.1777569959331E-01	9.42E+05	3.1777569959331E-01	1.601338E-12
3.1467612866441E-01	1.08E+06	3.1467612866441E-01	1.122325E-12
3.1166925884635E-01	1.25E+06	3.1166925884635E-01	7.866008E-13
3.0875231857052E-01	1.43E+06	3.0875231857052E-01	5.513024E-13
3.0592261896694E-01	1.65E+06	3.0592261896694E-01	3.863894E-13
3.0317755142677E-01	1.90E+06	3.0317755142677E-01	2.708074E-13
3.0051458523117E-01	2.18E+06	3.0051458523117E-01	1.897998E-13
2.9793126524569E-01	2.51E+06	2.9793126524569E-01	1.330243E-13
2.9542520967935E-01	2.88E+06	2.9542520967935E-01	9.323220E-14
2.9299410790702E-01	3.31E+06	2.9299410790702E-01	6.534329E-14
2.9063571835413E-01	3.81E+06	2.9063571835413E-01	4.579689E-14
2.8834786644217E-01	4.38E+06	2.8834786644217E-01	3.209748E-14
2.8612844259371E-01	5.04E+06	2.8612844259371E-01	2.249603E-14
2.8397540029547E-01	5.80E+06	2.8397540029547E-01	1.576670E-14
2.8188675421802E-01	6.67E+06	2.8188675421802E-01	1.105034E-14
2.7986057839063E-01	7.67E+06	2.7986057839063E-01	7.744805E-15
2.7789500442984E-01	8.82E+06	2.7789500442984E-01	5.428069E-15
2.7598821982030E-01	1.01E+07	2.7598821982030E-01	3.804347E-15
2.7413846624638E-01	1.17E+07	2.7413846624638E-01	2.666337E-15
2.7234403797334E-01	1.34E+07	2.7234403797334E-01	1.868744E-15
2.7060328027633E-01	1.54E+07	2.7060328027633E-01	1.309739E-15
2.6891458791623E-01	1.77E+07	2.6891458791623E-01	9.179508E-16
2.6727640366069E-01	2.04E+07	2.6727640366069E-01	6.433602E-16

Table D.5. Recommended Characteristic Curves for the Base Mat Surrogate (continued).

Saturation	**Suction Head (cm)**	**Saturation**	**Relative Permeability kr (Ksat = 3.5E-08 cm/s)**
2.6568721684928E-01	2.35E+07	2.6568721684928E-01	4.509091E-16
2.6414556200132E-01	2.70E+07	2.6414556200132E-01	3.160267E-16
2.6265001746519E-01	3.10E+07	2.6265001746519E-01	2.214923E-16
2.6119920410801E-01	3.57E+07	2.6119920410801E-01	1.552363E-16
2.5979178404432E-01	4.10E+07	2.5979178404432E-01	1.087998E-16
2.5842645940274E-01	4.72E+07	2.5842645940274E-01	7.625405E-17
2.5710197112947E-01	5.43E+07	2.5710197112947E-01	5.344385E-17
2.5581709782750E-01	6.24E+07	2.5581709782750E-01	3.745696E-17
2.5457065463050E-01	7.18E+07	2.5457065463050E-01	2.625229E-17
2.5336149211038E-01	8.25E+07	2.5336149211038E-01	1.839933E-17
2.5218849521744E-01	9.49E+07	2.5218849521744E-01	1.289546E-17
2.5105058225228E-01	1.09E+08	2.5105058225228E-01	9.037985E-18
2.4994670386835E-01	1.25E+08	2.4994670386835E-01	6.334413E-18
2.4887584210437E-01	1.44E+08	2.4887584210437E-01	4.439572E-18
2.4783700944567E-01	1.66E+08	2.4783700944567E-01	3.111544E-18
2.4682924791360E-01	1.91E+08	2.4682924791360E-01	2.180774E-18
2.4585162818216E-01	2.19E+08	2.4585162818216E-01	1.528430E-18
2.4490324872099E-01	2.52E+08	2.4490324872099E-01	1.071224E-18
2.4398323496411E-01	2.90E+08	2.4398323496411E-01	7.507840E-19
2.4309073850340E-01	3.34E+08	2.4309073850340E-01	5.261987E-19
2.4222493630626E-01	3.84E+08	2.4222493630626E-01	3.687946E-19
2.4138502995666E-01	4.41E+08	2.4138502995666E-01	2.584755E-19
2.4057024491885E-01	5.08E+08	2.4057024491885E-01	1.811565E-19
2.3977982982315E-01	5.84E+08	2.3977982982315E-01	1.269664E-19
2.3901305577305E-01	6.71E+08	2.3901305577305E-01	8.898641E-20
2.3826921567307E-01	7.72E+08	2.3826921567307E-01	6.236752E-20
2.3754762357666E-01	8.88E+08	2.3754762357666E-01	4.371124E-20
2.3684761405371E-01	1.02E+09	2.3684761405371E-01	3.063570E-20

APPENDIX E. DESIGN CHECK DOCUMENTATION

Kenneth Dixon/SRNL/Srs
10/16/2007 10:21 AM

To Margaret Millings/SRNL/Srs@Srs
cc Mark Phifer/SRNL/Srs@Srs
bcc
Subject Design Check for FTF Materials Report

Please design check the document WSRC-STI-2007-00369 titled "Hydraulic and Physical Properties of Tank Grouts and Base Mat Surrogate concrete for FTF Closure".

Associated files:

\\kddawg\Tank1

Design check instructions:

1)Check that the property values and ranges given in the report tables are consistent with those given in the data reports from MCT, GTX, and INL.
2)Check that the property values and ranges listed in the text of the report match those given in the data tables.
3)Check the hydraulic conductivity curves and the water retention curves to ensure they look reasonable for the various cementitious materials.
4)Check the van Genuchten transport parameters to ensure they look reasonable for the various cementitious materials. Check the files associated with the parameter estimation.
5)Verify that the logic of the report is sound and that the conclusions and recommendations are reasonable based on the results of the testing.

Thanks,
Ken
5-5205

Margaret Millings/SRNL/Srs
10/17/2007 04:39 PM

To Kenneth Dixon/SRNL/Srs@srs
cc
bcc
Subject Re: Design Check for FTF Materials Report

Ken,
I finished the design check and it looks good -- only minor changes/comments. The report was well written and easy to follow. Your logic, conclusions and recommendations appear to be reasonable and in-line with the test results.

I checked most (if not all) the property values and ranges on the tables (and in the text) of the report versus the laboratory reports. I had a few questions (see numbered items below).

I also spot checked the values listed on the report tables versus the Excel spreadsheets (including verifying formulas). The specific spot checks are noted on the hard copy of the report that I'll give back to you. I did not find anything that looked questionable (except for #8 listed below).

The hydraulic conductivity curves and water retention curves looked reasonable -- where we had data, the curves appeared to match up with the laboratory data.

I checked the van Genuchten parameters listed on your tables versus those you had listed in the Excel spreadsheet. I also checked the formulas on the Excel spreadsheet to make sure that they referenced the correct cells on the spreadsheet. I spot checked four RETC output files to make sure that the parameters listed (e.g., Theta r, alpha and n) matched those listed on your summary table.

Here are a few items you may want to check (most are just editorial suggestions):

1. Top of page 5 first paragraph -- "88 feet diameter and 12' high" -- maybe spell out the ' symbol to make it consistent within the sentence
2. Bottom of page 5 under "a" - should there be F or C listed with the temperature given?
3. Page 6, dot after "d" -- delete one of the periods at the end of the sentence.
4. Page 11, the first full paragraph -- check the 5.0 x 10-10 cm/sec minimum listed for the INL measurements of reducing fill grout (should it be 4E-10?)
5. Page 11, the first full paragraph -- the range listed for the INL measured porosity of the reducing fill grout -- I didn't see these values listed on a table (either in your report or the INL report -- I may have missed them??? I didn't check these values against anything)
6. You may possibly add how particle density was calculated in the footnotes of your hydraulic property tables??? If you do, you may also want to specify which porosity you used in the calculation.
7. You may possibly want to add in the footnote of some of your hydraulic property tables that the values shown were from effective confining pressure of 10psi (versus 40psi -- since you have some of these reports in your appendix).
8. Check the hydraulic conductivity value listed for TNK010B on Table 19. It's listed as 2.6E-8, but I thought that the report said 3.1E-8. The Excel spreadsheet has 2.6E-8.
9. Check the maximum particle density listed for the Base Mat Surrogate on Table 20. It's listed as 2.53 -- I was wondering whether it should be 2.55?
10. Check the footnote number listed at the bottom of Table 22 -- there's a 1 and 3 (I'm thinking that the 3 should be a 2).
11. Check the footnotes on Tables 24 and 25 -- the footnotes are listed, but no numbers appear on the table. It looks like "Sample ID" should have a 1 and "Location" should have a 2???
12. Check the second Sample ID listed on Table 24. It's listed as TNK029A2 but looking at the data I was wondering whether it should be TANK028A2?
13. Check the bulk density value and porosity value listed on Table 29 (Recommended Hydraulic Property Values) for the Strong Grout. Based on Table 20, I thought maybe the bulk density should be 1.80 and porosity should be 0.269 (neither of these are far off from what you have on the table, but it might be confusing to some people why the values are different from Table 20???)

14. Check the footnotes on Table 30 -- footnote #2 doesn't appear on the table.

If you have any questions, let me know.

Maggie

Kenneth Dixon/SRNL/Srs

Kenneth Dixon/SRNL/Srs
10/16/2007 10:21 AM

To Margaret Millings/SRNL/Srs@Srs
cc Mark Phifer/SRNL/Srs@Srs
Subject Design Check for FTF Materials Report

Please design check the document WSRC-STI-2007-00369 titled "Hydraulic and Physical Properties of Tank Grouts and Base Mat Surrogate concrete for FTF Closure".

Associated files:

\\kddawg\Tank1

Design check instructions:

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4)Check the van Genuchten transport parameters to ensure they look reasonable for the various cementitious materials. Check the files associated with the parameter estimation.
5)Verify that the logic of the report is sound and that the conclusions and recommendations are reasonable based on the results of the testing.

Thanks,
Ken
5-5205

Margaret Millings/SRNL/Srs
10/19/2007 07:21 AM

To Kenneth Dixon/SRNL/Srs@srs
cc
bcc
Subject Re: Design Check for FTF Materials Report

Ken,
Sounds good. Sorry I didn't realize that the 120 was position -- it definitely makes more sense as position.

Maggie

Kenneth Dixon/SRNL/Srs

Kenneth Dixon/SRNL/Srs
10/18/2007 04:54 PM

To Margaret Millings/SRNL/Srs@Srs
cc
Subject Re: Design Check for FTF Materials Report

Maggie,

I have addressed all your comments. I agreed with all comments except comment 2. The 120° indicates position rather than temperature. Thus, no change was made for comment 2. The revised report is in my public folder at the following path:

\\kddawg\Tank1

If you agree that I have adequately addressed your comments, please send an e-mail to that effect.

Thanks,
Ken
5-5205

Margaret Millings/SRNL/Srs

Margaret Millings/SRNL/Srs
10/17/2007 04:39 PM

To Kenneth Dixon/SRNL/Srs@srs
cc
Subject Re: Design Check for FTF Materials Report

Ken,
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