WSRC-RP-2005-01675
Revision 0

Keywords: Tank Closure
Tank 17-F Closure
Strong Grout

Retention Time: Permanent

HLW TANK INTRUDER DETERRENT GROUT (U)

Christine A. Langton

April 26, 2005

APPROVED for Release for
Unlimited (Release to Public)

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

Prepared for the U.S. Department of Energy Under Contract Number DE-AC09-96SR18500

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SAVANNAH RIVER NATIONAL LABORATORY

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SUMMARY

The 2000 psi grout in the tank dome can be considered to be a man-made sedimentary rock-like material. It consists of insoluble quartz sand in a matrix of calcium silicate hydrates and other hydrated phases that bind the sand together. It is not possible to drill through such a material with the standard well drilling equipment used for unconsolidated sediments in Aiken County.

The ability or ease of drilling in soil and sediment is commonly evaluated by measuring the resistance to penetration by one of several methods, for example ASTM D-1586 [1]. Although compressive strength is not a direct measurement of ease of drilling, resistance to penetration and compressive strength are directly related [2].

The cement grout placed in the domes of Tanks 17-F and 20-F was sampled during production. The compressive strengths were measured and were greater than 2000 psi after curing. This tank dome grout is essentially impenetrable per the test ASTM D-1586 and therefore can not be drilled with standard equipment used to penetrate soils.

Aging of the 2000 psi grout is not expected to significantly reduce physical stability of this material in the tanks. Factors which are known to affect the physical stability of cementitious materials are listed in Figure 1. Physical factors which result in loss of mass by wind and water erosion were determined to be minimal [3].

Mechanical cracking can be caused by overloading the material due to poor design or to geological events such as earthquakes or subsidence. Structural overload of the grout in the tank dome is unlikely because the load requirement is the same as that of compacted soil. Geological events that may overload the grout can fracture the 2000 psi grout in the tank dome. However, these events will not remove material, and the load bearing capacity of the unit is not expected to be reduced to less than that of the surrounding soil.

Chemical factors that impact durability of cementitious materials (concrete in particular) were taken into account in designing the 2000 psi grout used to fill the tank dome. Quartz sand was selected as the aggregate and it is very insoluble in water and acid rain. It is also resistant to microbial degradation. The cementitious binder is a blend of hydrated cement and hydrated pozzolans, slag and fly ash, and was designed to have a low solubility. Consequently, the 2000 psi grout is expected to remain recognizably different than soil and in place until physical factors such as erosion come into play.

The grout in the tank domes was designed to minimize the chemical factors that can lead to cracking caused by shrinkage or expansion. In most cases, desiccation being the exception, cracking is due to the addition of mass rather than removal of mass. In the special case of carbonation of calcium hydroxide and calcium silicate hydrate, the 2000 psi grout will be slowly converted to calcite (calcium carbonate) and silica gel (amorphous hydrated silica) which are both cementitious. As the result of aging, carbonation will transform the grout from a man-made sandstone-like rock with a hydrated calcium silicate matrix to a sandstone-like rock with a calcite-silicate (aged hydrated portland cement-pozzolan) matrix.

If cracking does occur, the hydraulic conductivity of the grout will be affected but even in a cracked state the structural requirements will be met. This is in contrast to structural concrete in which cracking will accelerate corrosion of rebar and the transmission of load to the rebar. For free standing reinforced structural concrete members and supported reinforced concrete slabs, transmission of load per the design requirements is critical because performance in tension, flexion and shear are typically required in addition to performance in compression.

Finally, models/methodologies have been developed for predicting changes in physical properties of material in response to chemical and physical factors as a function of time. Empirical, theoretical, mechanistic, and probablistic models are sometimes used in addition to analogies with geologic and ancient man made materials. To date only simplistic models have been applied to the tank closure grouts to describe the consequences of postulated bounding (worst) cases. Initial mechanistic evaluations indicated that the grout would only be exposed to infiltrating rain water and geologic forces. Consequently, mechanisms for significant loss of material or expansive reactions in the 2000 psi capping grout were not identified.

In conclusion, the 2000 psi grout placed in the domes of closed tanks at SRS is expected to provide a deterrent to inadvertent intrusion over long periods of time because it will retain the characteristic of being a recognizable unit different from the surrounding soil even if it is cracked into small pieces. This is supported by many examples of ancient concrete structures (>2000 years old) and cement based building materials (plasters and mortars > 5000 years old) provide evidence that cementitious materials survive as recognizable units with physical properties similar to those obtained at the time of construction [4, 5]. If cracking of the 2000 psi grout in the tank dome does occur as the result of events that occur over the long term, the cracked material will still pose a problem to drilling with standard equipment. Gravel, rubble, and cobbles are all very difficult to penetrate with soil drilling equipment. Encountering cobbles is a common reason cited for drilling refusals in the coastal plain sediments at the Savannah River Site.

- Physical Factors
  - Loss of Mass
    - Erosion
      - Water
      - Wind
  - Mechanical Cracking
    - Overload
    - Biointrusion
    - Freeze Thaw
    - Thermal Stress
    - Geological Stress
      - Earthquakes
      - Subsidence

- Chemical Factors
  - Loss of Mass
    - Desiccation (Early water loss) ⟶ Cracking
    - Dissolution/Leaching ⟶ Increased Porosity
      - Water
      - Acids
      - Microbial degradation
  - Addition of Mass (Expansion) ⟶ Cracking
    - Sulfate (Ettringite)
    - Alkali (ASR hygroscopic gel)
    - Fe (rebar) + Oxygen, Carbonate, Chloride
  - Addition of Mass ⟶ Fill/Seal Cracks and Pores
    - Carbonate (Calcium Carbonate Precipitation)

Figure 1. Physical and Chemical Factors Related to Grout Stability

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