EXTENDED ABSTRACT
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Optimization of Remedial Design For Remediation of SRS's Radioactive Seepage Basins By In-Situ Stabilization/Solidification

The Savannah River Site recently began remediation of several radiologically contaminated basins using in-situ stabilization. These unlined basins contain radiological contaminants, which potentially pose significant risks to human health and the environment. The Records of Decision and conceptual remedial design for these remedial actions were approved by the U.S. Environmental Protection Agency and the South Carolina Department of Health and Environmental Control.

A common and cost-effective remedy was selected for such radioactively contaminated basins with similarities in history of use, contaminants, risk, and location. The selected remedy entails in-situ stabilization/solidification (S/S) of the contaminated wastes (basin and pipeline soils, pipelines, vegetation, and other debris) followed by installation of a low permeability soil cover. After closure land use controls and long term maintenance will be continued. The remedial action will ensure that the following remedial objectives are met:

- minimize contaminant migration and treat potential threat source materials
- protect site workers and future residents from direct exposure to radiation
- reduce infiltration, intrusion, and surface erosion

In-situ S/S of two such basins (known as lead basins) were completed by spring of 2001, while remediation of other basins continues. Lessons learned from these projects are being used to optimize the remedial design and construction requirements for S/S of similar radioactive basins at SRS. Activities performed for S/S of wastes in the lead basins were:

- Demonstration of the selected S/S technology and process in a clean area
- Pilot testing for optimization of the grout mix and the S/S technique followed by final in-situ S/S of all basin wastes.
- Verification of completion of successful S/S

Shallow soil mixing technique with single auger equipment was used for the S/S treatment of lead basins. Verification of completion of S/S was performed through quality control inspection and testing of S/S waste samples. The performance requirements were designed based on the results of a treatability study and US EPA guidance documents. 28-day compressive strength and leachability were the primary acceptance criteria for the S/S waste. Secondary criteria, for S/S process control, were hydraulic conductivity, pH, temperature, gas generation, radiation exposure, effects of nitrite/nitrate, sulfite/sulfate, strength of the S/S waste under immersed and irradiated conditions, etc.

Laboratory-scale grout mix design process was used to develop required grout mixes for S/S treatment. Grout mixes were composed of Portland cement mixed with several combinations of silicate, bentonite, fly ash and super plasticizer (in a few applications to enhance mixing operation).

Typically, soil types ranged from silty-sand to clayey sand to sandy clay. Multiple pilot tests were necessary to establish the operational parameters (e.g., grout flow rate, mixing time, number of passes, etc.) for mixing the clayey soils at basin bottom. During the mixing process it was observed achievement of uniform mixing was difficult in predominantly clayey soil zones. In overlap areas, excess grout caused high temperature of hydration during curing resulting in thermal cracks through the grouted mass. In addition, significantly large number of test samples was required for verification of grouted waste. Consequently, the process of mixing, sample collection, analysis and testing became very involved and expensive.

Optimization of S/S design is summarized below:

- Through a common bench-scale grout mix design process a set of grout mixes were development for S/S treatment of multiple basins having similar characteristics and radiological contamination. The results of the new study and those performed for the S/S of the lead basins consistently demonstrated that all of the Portland cement based grout mixes effectively stabilized the treated waste. The compressive strength, leachability and hydraulic conductivity test results of the stabilized waste samples met the requirements.

- Field observations indicated that majority of the nonconformance resulted from inadequate mixing of the soil grout. Therefore, achievement of a reasonably uniform mixing was critical to the successful accomplishment of the S/S process. It was determined that the S/S mixing equipment should be capable of delivering a high energy and high shear mixing action to thoroughly mix the clayey soil with the injected grout. In addition, the basin soils and the grout mix would require monitoring of moisture content and soil density to ensure flowability of the design grout mix.

- Grout mix treatability studies and lessons learned from the lead basin stabilization indicated that presence of low levels of chloride, nitrite, nitrate, sulfate and sulfide in the basin soils had little to no adverse effect. Similarly, evaluation of effects gas generation was also found unnecessary, because gas generation from low-level radioactive waste forms was not significant enough to create any adverse effect. Therefore, those tests were eliminated.

- Considering that the pre-qualified grout mixes consistently met the low permeability requirement and also that a low permeability soil cover will be installed atop the S/S waste, further testing of hydraulic conductivity for verification of S/S was considered redundant. Testing under immersed conditions was also discarded as unrealistic condition.

- Based on past experiences, there is no report of any significant adverse effect of low level radiation on concrete or cement based materials. In addition, because of the effect of decay in radiological activities and the effect of dilution from mixing of clean grout mix with other minimally contaminated excavated soils, the radiation dose absorbed in the stabilized waste will be less than the existing low level radioactivity in the basin sediments. Therefore, the requirement of radiation exposure tests on the grout mix or the stabilized waste was considered redundant.

- Detailed evaluation of effect of high heat of hydration indicated that it was important to monitor the temperature differential between the surface and core of the grouted mass to minimize thermal cracking. An insulating layer of soil on top of the stabilized waste effectively kept the temperature differential that produced no significant thermal cracking.

Based on above optimization studies, it was concluded that the optimized acceptance criteria for the final in situ stabilized/solidified should be: a) visual inspection of uniformity of the soil-grout mixture core samples, and b) verification of unconfined compressive strength and leachability, tested per applicable industry standards. The requirements for monitoring of density and moisture content of the soil grout, pH and temperature were kept for process control during the S/S process.

Author: Amit Ganguly , 730-2B, SRS, Aiken, SC. 29808. Tel: (803)-952-6888; Fax.: (803)-952-6628

Biography of Author:

Amit Ganguly is a Principal Engineer with Bechtel Savannah River Inc. He is currently working as the Technical Lead and the Engineering Design Authority for several remediation projects in the Environmental Restoration Division at the Savannah River Site. He has Master's degree (M.Tech) in Civil/Structural Engineering from the Indian Institute of Technology at Kharagpur, India and also M.S. from the Washington University at St. Louis, MO. He is also a Certified Manager (CM), certified by the Institute of Certified Professional Managers and sponsored by the National Management Association, SRS branch.
