S/S Treatment of Dioxin Soils at Naval Construction Battalion Center Gulfport

By: Raghu Arora, Joe Shaiman, and Ganesh Subramaniam, ECC

Introduction

Two portland cement applications, cement-based solidification/stabilization and roller-compacted concrete pavement, are being used to remediate and manage dioxin-contaminated sediment at the Naval Construction Battalion Center in Gulfport, Mississippi.

Cement-based solidification/stabilization (S/S) is a treatment used on contaminated media (such as soil, sediment, or sludge). The treatment involves mixing portland cement into contaminated media. S/S protects human health and the environment by immobilizing contaminants within the treated waste or media.

Roller-compacted concrete (RCC) consists of an engineered mixture of dense-graded aggregates, portland cement, and water. This "low-slump" concrete mixture is placed with an asphalt paver and compacted to high density with vibrating rollers. Roller-compacted concrete pavement is more economically placed than conventional concrete, since it is placed without formwork, conventional finishing, or reinforcing steel. The result is a strong, durable pavement readily adaptable for heavy wheel loads.

The Naval Construction Battalion Center (NCBC) is located in the southeastern corner of Mississippi, approximately two miles north of the Gulf of Mexico. NCBC has served various purposes; among these was use as a base for the famous naval construction battalions the "Fighting SeaBees," a naval training center, and custodian of certain national stockpile materials (such as bauxite, tin, copper, and sisal). One material stored at NCBC was an herbicide known as Herbicide Orange (HO). HO was one of the defoliants used during the Vietnam War.

Excavation of sediment from dranage ditches

S/S treatment: Mixing by road reclaimer

Herbicide Orange Storage

HO was stored at NCBC at an area called Site 8. Site 8 consists of three contiguous storage areas (Areas A, B, and C, hereinafter referred to as Site 8A, Site 8B, and Site 8C) located in the north-central portion of NCBC. The main former HO drum storage area, Site 8A, which encompasses approximately 13 acres (5.3 hectares), has an undulating surface due to previous remedial activities and is covered with light vegetation. Prior to 1968, Site 8 was used as an equipment storage and staging area. Around 1961, the surface soils were stabilized with portland cement to provide a hardened surface for heavy equipment operation and storage. Between 1968 and 1977, Site 8 was used by the United States Air Force (USAF) as a storage area for drums containing HO. Site 8A was used to store approximately 850,000 gallons (3,200,000 liters) of HO. In 1977, the HO drums were removed from Site 8, transported to port by railroad, and placed on a ship for destruction by incineration in the South Pacific.

HO is an herbicide formulation using an equal mixture of two agricultural herbicides-2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)-in diesel fuel or jet fuel. Spills and leaks of HO within Site 8 contaminated the surface soil and sediment with 2,4,5-T and 2,4-D, as well as by-product contaminants (dioxins and furans), primarily 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The release of dioxins at Site 8 was confirmed in 1977, and the site was fenced and left inactive until 1985. In 1985, the USAF began operations to clean up the dioxin-contaminated soils that remained on site following the removal of the drums of HO. With a Research, Development and Demonstration permit obtained through the United States Environmental Protection Agency (EPA), Region IV, the USAF conducted test burns to demonstrate that incineration was capable of reducing dioxin concentrations in site soils to less than the EPA criterion (as of 1985) of 1.0 microgram per kilogram (µg/kg). During the test burns, two additional areas (Sites 8B and 8C) outside the original 13 acres (5.3 hectares) were identified and verified as previous storage locations for drums containing HO. Following EPA acceptance of the test burn data, full-scale incineration of dioxin-contaminated soils from all three sites was conducted within the boundaries of Site 8A and completed in 1988. The ash (soil ash) that remained from the incineration process was stored on Site 8A. Although the soils within Sites 8A, 8B, and 8C were incinerated, the drainage channels that carry surface water and sediment from these sites to the lower reaches of the local drainage basin and the off-base Area of Concern (AOC) (wetlands) area of approximately 500,000 square feet (50,000 square meters) were not addressed during this remedial effort.

Impacted Ditch and Wetland Sediment Remedy

The selected remedy for HO-impacted ditch and wetland sediment consisted of the following components:

- Performance of a bench-scale treatability study to identify treatment parameters capable of achieving acceptable physical and chemical criteria for remediation.
- Excavation of dioxin-contaminated sediment from on-base drainage channels contiguous to Site 8 and from an associated off-base wetland AOC located north of the base and excavation of soil ash located at Site 8A.
- Consolidation, homogenization, and solidification/stabilization of soil ash and contaminated sediment within a portion of Site 8A. The S/S-treated material to be used as subbase and base course for pavement.
- Construction of a roller-compacted concrete pavement as a cap over the S/S-treated material.
- Performance of verification sampling at on-base drainage channels and off-base areas.
- Restoration of the on-base drainage channels and off-base AOC affected by excavation activities.

Table 1: Quantities of Contaminated Sediment and Soil Ash Involved

Material	Quantities
On-base drainage channels	33,000 tons (30,000 metric tons)
Off-base area of concern	45,000 tons (41,000 t)
Soil ash on 8A	24,800 tons (22,000 t)

Table 2: Performance Goals of S/S Treatment and RCCP

Parameter	Test Value
Geotechnical testing of S/S-treated material used as subbase course layer	50 psi (0.34 MPa) UCS
Geotechnical testing of S/S-treated material used as base course layer	500 psi (3.4 MPa) UCS
Dioxin leachability criteria	30 picograms/liter by SPLP
Roller-compacted concrete	550-psi (3.8-MPa) flexural and 4000-psi (28 MPa) compressive strengths

Table 3: Portland Cement Addition

Parameter	Portland Cement Addition
Portland cement for subbase layer (50-psi strength)	4.7% - 7% addition
Portland cement for base course layer (500-psi strength)	14% addition

Remediation Goals and Performance Standards

Sediment with dioxin concentrations greater than 38.2 nanograms/kilogram (ng/kg) would be excavated from the affected areas and treated. One ng/kg corresponds to one part per trillion. Table 2 lists performance standards for S/S treatment and RCCP.

Subbase Test Section Construction

A test section was required to prove that S/S treatment of the three types of contaminated material (off-base sediment, on-base sediment, and soil ash) would meet performance goals set for the subbase. The test section consisted of approximately 3,000 cubic yards (2,300 cubic meters) of S/S treated material.

A test section of S/S-treated material was constructed in two lifts (layers).

First Lift - 1521 cu yd (1163 m^3) of on-base and off-base material and ash was used to build the first lift for field demonstration. The average dimensions of the plot were 158 ft by 260 ft (48 m by 79 m). Area of the plot was 41,080 sq ft (3816 m^2). The first lift required 607 cu yd (464 m^3) of wetland sediment, 426 cu yd (326 m^3) of ditch sediment, and 487 cu yd (372 m^3) of soil ash, or 853 tons (774 t), 634 tons (575 t), and 623 tons (565 t) respectively. Twelve-inch (300-mm) lifts of on-base and off-base sediments were placed next to each other. Soil ash was placed on top of these off-base and on-base materials and blended with a bulldozer. A cement spreader distributed cement over the surface of the materials to be treated. Approximately 100 tons (90 t) of portland cement (4.7%) was used. A soil stabilizer , also referred to as a "road reclaimer", was used to mix the spread layered materials together. The resulting S/S-treated blend was compacted to 12 in. (300 mm) using a vibratory compactor.

Succesive lifts, S/S treated by mixing with road reclaimer

Second Lift - A second lift of treated material was constructed using similar materials placement, mixing, and compaction methods as in the first lift. 1428 cu yd (1092 m^3) of on-base and off-base material and ash was used to build this second lift. The cement addition rate was 4.7% for this lift.

Base Test Section Construction

A test section was required to prove that S/S treatment of the wetlands and ditch sediments would meet performance goals set for the base layer. The test section consisted of approximately 220 cu yd (170 m^3) of S/S treated material. A test section of 120 ft by 75 ft by 7 in thick (37 m by 23 m by 180 mm) was constructed by mixing cement into contaminated sediments. Approximately, 173 tons (157 t) of wetland sediment, 113 tons (103 t) of ditch sediment and 46 tons (42 t) of cement powder were mixed to form the section.

A proportioned blend of wetland and ditch sediment was uniformly mixed and graded to the test section dimensions using a bulldozer and soil stabilizer. Initial moisture content of the test section was approximately 23%. After airing out and exposing the sediment blend to sun light for period of three days, the moisture of the sediment blend was brought down to 15%.

Cement was placed on top of the sediment blend using a spreader powered by tractor. Five spreader loads of cement were placed at an average rate of 9.28 tons/load (8.42 t/load). The approximate amount of cement placed in the entire pad was 14% by weight of the sediment blend. The bulldozer was used to spread the cement evenly on sediment blend followed by soil stabilizer mixing the cement into the sediment blend. A compactor followed the soil stabilizer after it mixed the cement with sediment blend. The number of compactor passes used to achieve the required 95% maximum density were four on vibrate and one on standard operation.

Test Section Results

Unconfined Compressive Strength (UCS) Results

UCS testing was performed on the sub-base and base test sections using American Society for Testing and Materials (ASTM) Method 1633. Peformance standard for UCS was set at 50 psi (0.34 MPa) for the subbase and 500 psi (3.4 MPa) for the base. The test results for the subbase section at 11 days cure time ranged from 80-110 psi (0.55-0.76 MPa). For the base section, test results at 7 days cure were 660 psi (4.6 MPa).

Dioxin Leachability Test

The Synthetic Precipitation Leaching Procedure (SPLP) (EPA SW-846 Method 1312) was preformed on one core sample from UCS testing. The SPLP leachate (extract) was analyzed for polychlorinated dibenzodioxins (dioxins) and polychlorinated dibenzofurans (furans) using EPA SW-846 Method 8290. The performance standard set for leachability of dioxin was 30 picograms/liter by SPLP. Analytical results of laboratory testing for dioxin in the leachate indicated "non-detect," confirming effectiveness of S/S treatment.

Full Scale S/S Treatment Resulting in Subbase and Base Layers

Full-scale mixing similar to the test sections was implemented to create subbase and base layers over an area of 13 acres (5.3 hectares). The amount of sediment stabilized in this area was approximately 87,000 tons (79,000 t). Soil ash taken from storage was mixed into the sediment during the S/S treatment with a 4.7% addition of cement. The supply of soil ash ran out part way through the subbase construction. A 7% addition rate of cement was used to complete the subbase. Water was rarely added during the S/S treatment of the sediment, since the wetland and ditch sediment was usually saturated with water from heavy rains and S/S-treated layers were wetted with rain after placement. A crowned contour of the treated sediment was achieved by varying the number of lifts. Some locations had up to 5 lifts composing the subbase. Geotechnical unconfined compressive testing was done once every 13,000 tons (12,000 t) of stabilized material. Dioxin testing was done every 7,000 tons (6,000 t) of stabilized material.

The base layer was made with one lift across the top of the sub-base layer. In order to achieve the higher UCS of the base layer-500 psi for the base layer versus 50 psi for the subbase-a richer addition of portland cement was used: 14% portland cement addition for the base layer versus 5%-7% for the subbase layer. No soil ash was mixed into this layer since the supply ran out during construction of the subbase.

Testing confirmed that the UCS performance standards were met and the dioxin leaching results were "non-detect".

Verification Sampling and Site Restoration

All verification samples from on-base and off-base were analyzed by EPA SW-846 methods 4025 and 8090 and were within the 95% upper confidence limits of the preliminary remediation goal of 38 ng/kg. The ditches were restored with top soil, seeded, and erosion control matting was placed. The wetlands excavated areas were backfilled with 12 inches (300 mm) of common fill followed by 6 inches of top soil.

Future Work: Roller-Compacted Concrete Pavement

In the future, the contractor will place 12 inches (300 mm) of roller-compacted concrete over subbase and base layers. This will be done in two 6-inch (150-mm) lifts. Testing requirements include a 28-day compressive strength of 4000 psi (28 MPa) at 28 days and flexural strength of 550 psi (3.8 MPa). This heavy duty pavement will be used for storage of heavy equipment on the base.

Credits

Property Owner:
U.S. Navy

Remediation Designer:
TetraTech NUS, Pittsburgh, OH

S/S Treatment Contractor:
ECC, Bloomfield, NJ

Photographs:
ECC, Bloomfield, NJ

PCA
Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9781
www.cement.org

An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

Cement Association of Canada
Association Canadienne du Ciment
www.cement.ca