



Treated Soil Recycled for Use in Parking Lot Construction at Naval Support Activity, Mechanicsburg, Pennsylvania

Introduction

The Naval Facilities Engineering Command (NAVFAC) is currently working with Encapco Technologies, LLC to test their patented emulsion stabilization technology at several sites for the treatment of soils impacted by heavy metals, explosive compounds, radionuclides, and other contaminants. The Encapco technology involves mixing contaminated soil into an asphalt or tall oil pitch (TOP) emulsion that is chemically enhanced to bind and stabilize the target contaminants. The stabilized and encapsulated soil is then ready for reuse as a valuable construction material for road base, covers, berms, or fill. The objectives of NAVFAC's on-going demonstration program are to evaluate the implementability of the Encapco soil stabilization technology, to document the cost and performance of the technology, and to obtain regulatory support for the overall treatment approach and product reuse options. This article summarizes the results of the Encapco demonstration project at the Naval Support Activity (NSA) in Mechanicsburg, Pennsylvania including the site background, project-specific objectives, technology implementation, and primary conclusions of the cost and performance assessment.

Site Background

NSA Mechanicsburg was commissioned during World War II as an inland supply depot to support Navy operations worldwide. The primary mission of NSA Mechanicsburg is to procure, store, and maintain certain strategic and critical materials important to the Navy's national defense mission. The facility is home to numerous commands such as the Naval Inventory Control Point, which manages the inventory control for a broad range of goods and services used in ships, submarines, ship weapon systems, naval aircraft, and aircraft weapon systems. Another important tenant unit is the Navy Ammunition Logistics Center, which is responsible for maintaining a supply of lead and zinc destined to become part of the U.S. Navy's ammunition. NSA Mechanicsburg has served as a repository for approximately 90,000 tons of lead and zinc ingots that were stored outdoors since the early 1950's in four storage areas numbered 317, 413, 414, and 606 (See Figure 1). This practice left the ingots exposed to decades of weathering and resulted in an impact to the surrounding soil with lead and zinc. The ingots were removed from all outdoor storage areas in 2002 and placed in covered warehouses.

Based on discussions with project stakeholders including Base personnel and regulatory agencies, it was decided to conduct the Encapco demonstration project at Storage Area 413 and to reuse the resulting Encapco-treated soil product as the base for a nearby parking lot. Lead and zinc were the only soil contaminants known to exceed human health exposure criteria at Area 413. A previous site investigation around Area 413 verified lead and zinc contamination in surface soils at concentrations of up to 20,400 milligrams per kilogram (mg/kg) and 3,720 mg/kg respectively. In addition, toxicity characteristic leaching procedure (TCLP) data from one soil sample collected during Encapco's site visit in June 2003 showed a concentration of 6.4 milligrams per liter (mg/L) of lead in the leachate, which exceeded the applicable hazardous waste threshold for lead.

Based on further site investigation activities in June 2003, it was determined that approximately 500 tons of soil at Area 413 would require excavation and treatment to meet human health exposure criteria for lead and zinc. It was also determined that the elevated lead and zinc levels were primarily located from the surface to a depth of 4-inches below ground surface (bgs) and that soils at a depth of 1 ft bgs were below the applicable human health criteria for lead and zinc.

Project Objectives

The purpose of this demonstration was to evaluate the effectiveness and cost associated with the Encapco process for treating lead and zinc contaminated soil at NSA Mechanicsburg. The following list summarizes the project-specific objectives:

- Evaluate lead and zinc levels in the surface soil at Area 413;
- Determine a suitable emulsion design for the clayey soil conditions at the site;



Figure 2. Lead ingots stacked within fenced area

- Evaluate the ability of the emulsion to reduce lead and zinc leaching from treated soil to below TCLP standards of <math><0.75\text{ mg/L}</math> for lead and <math><4.3\text{ mg/L}</math> for zinc; and
- Estimate costs and compare them with the costs of traditional soil disposal at a hazardous waste landfill.

Technology Implementation

Encapco's stabilization method can be implemented either ex situ or in situ. This physical-chemical treatment technology for the cleanup of contaminated soil was patented in 1999 under U.S. Patent No. 5,968,245 and is licensed by Encapco Technologies LLC. It involves mixing contaminated soil into an asphalt or tall oil pitch (TOP) emulsion that is chemically enhanced to bind and stabilize the target contaminants. During the Encapco process, chelating and/or precipitating agents are added into the asphalt emulsion to promote chemical bonding of the target contaminants. As the asphalt emulsion coalesces, cures, and solidifies, the contaminants in the soil are both chemically stabilized and physically encapsulated. The overall treatment objective is to minimize contaminant leaching, while retaining the overall adhesiveness, durability, and water-resistance of the final asphalt base product.

A typical emulsion formulation is provided in Table 1. A site-specific formula was developed for the NSA Mechanicsburg site based on the results of an initial treatability study (ITS) conducted in October 2002. The results of the ITS demonstrated that the Encapco emulsion could successfully stabilize the clayey soils from the site to achieve TCLP values of 0.4 mg/L for lead and 0.75 mg/L for zinc, which were well below the hazardous waste thresholds determined by the Resource Conservation and Recovery Act (RCRA).

Figure 2 shows the major equipment involved in the ex situ treatment process. A feed hopper is used for storage of excavated soil and a tanker truck is used to hold the asphalt or TOP emulsion. A pug mill mixer is then used to blend and thoroughly mix the soil and emulsion prior to placement into a dump truck. An array of mist spray bars and hoses are used for dust control. After treatment, the final product is a stabilized and encapsulated soil that can then be used for road base, covers, berms, fill, or other purposes.

Material	Volume
Tall Oil Pitch or Asphalt	50%
Non-ionic Surfactant	2%
Water	42%
Acid- Proprietary	6%

Table 1. Typical Emulsion Formulation

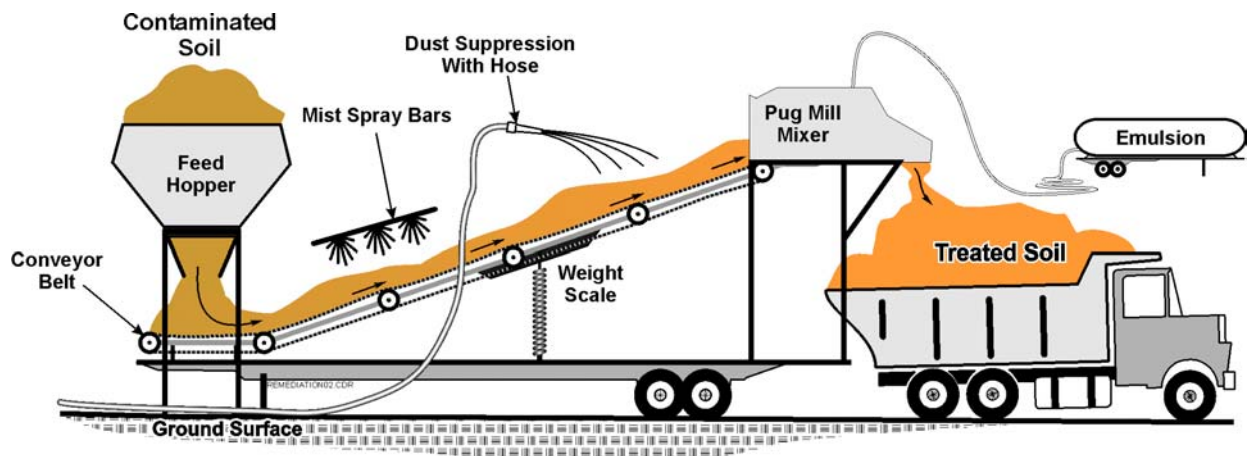


Figure 2. Encapco Treatment Schematic

The fieldwork at NSA Mechanicsburg was conducted from 6 October through 17 October 2003. The first step consisted of soil excavation and screening of approximately 700 tons of soil (see Figure 3a). After passing the soil through a screen and removing pieces of soil and gravel greater than one inch, approximately 500 tons of lead and zinc contaminated soil were deemed suitable for processing. Following excavation, the soil was placed in a temporary stockpile and quicklime was added to remove excess moisture. Subsequently, a tanker truck delivered the Encapco emulsion, which was mixed with the soil in a pug mill (Figure 3b). The liquid emulsion was delivered to the job site and was then proportioned and mixed with the soil at a temperature between 90°F and 120°F. The quantity of water added to the mixture was adjusted to produce the optimum moisture content of the soil. As the soil was mixed, a total of 10 pre- and post-treatment grab samples were obtained from the first 100-ton test run and at every 100-ton batch thereafter to provide data on the performance of the process. The samples were submitted for total lead and zinc analysis using USEPA Method 6010 and TCLP analysis using USEPA Method 1311/6010. After treatment, the soil was placed in a second temporary stockpile and covered with plastic sheeting, until the plans to use the asphalt mix as parking lot sub-base/base were implemented. Next, the treated soil was laid down in the

excavated area in 8-inch lifts and compacted with an 8 ton Ingersoll-Rand smooth wheel compactor (see Figure 3c). After compaction was completed, Encapco collected four in-place treated soil samples from the compacted sub-base/base of the parking lot. The samples were analyzed using USEPA Method 6010 for total lead and zinc and 1311/6010 for TCLP lead and zinc concentrations.



Figure 3. Encapco Treatment Process at NSA Mechanicsburg, PA
 From top to bottom the photographs show the following:
 (a) soil excavation and screening process;
 (b) pug mill and emulsion tanker truck; and
 (c) treated soil awaiting compaction and surfacing.

Performance Assessment Conclusions

The performance assessment for the NSA Mechanicsburg project included an evaluation of the reduction in contaminant mobility and leachability by comparing before and after treatment TCLP results for lead and zinc. The performance assessment also included the analysis of supplemental geotechnical criteria to assess the suitability of the emulsified soil product for reuse as sub-base/base for the parking lot including the treated product's permeability, stability, and flow under heavy loads. The after-treatment TCLP results from the compacted soil samples are summarized below in Table 2. As shown in Table 2, the TCLP values for lead were all less than 0.11 mg/L and met the RCRA TCLP standard of <0.75 mg/L for lead. The TCLP values for zinc were all less than 0.33 mg/L and met the RCRA TCLP standard of <4.3 mg/L for zinc.

The treated product showed a relatively low permeability ranging from 2.2×10^{-5} cm/s to 5.2×10^{-5} cm/s, but these values were still slightly elevated compared to the performance target of less than 1.0×10^{-5} cm/s. After optimization of the cement mix for the second and third test runs, the treated product was also able to meet the required strength and flow characteristics evaluated by the Marshall Test for use on roads subject to heavy traffic.

The total cost for the demonstration project is reported in Table 3, along with an analysis of the unit cost for the treatment of 500 tons of lead and zinc impacted soil at the NSA Mechanicsburg site. The major cost drivers for the Encapco process include equipment charges (including capital rental equipment costs, equipment repair, maintenance, and fuel), labor, material (including the Encapco mixture), permitting, utilities location, location surveying, oversight, and work plan/report

preparation. The unit cost for the demonstration project is relatively high due to the small volume of soil treated at 500 tons. However, it is still below literature values reported for excavation and off-site treatment and disposal, which are reported to range from \$200 to \$460 per ton for hazardous waste. Figure 4 shows the predicted effect of scale on the unit cost of Encapco treatment. For example, with

Sample ID	Pb (TCLP)	Total Pb	Zn (TCLP)	Total Zn
	mg/L	mg/Kg	mg/L	mg/Kg
Northwest	<0.11	746	<0.33	115
Northeast	<0.11	742	<0.33	121
Southwest	<0.11	761	<0.33	105
Southeast	<0.11	789	<0.33	130

Table 2. Total and TCLP Lead and Zinc Concentrations on Compacted Samples

7000 tons of soil, the unit cost per ton of treated soil would decrease to approximately \$43 per ton. Due to these scalability issues, 500 tons of soil is the minimum quantity of soil that is recommended to be treated by the Encapco process, while still maintaining its cost effectiveness compared to off-site disposal as hazardous waste.

Task Description	Cost
Treatability Study	\$5,800.00
Mobilization/Demobilization	\$5,878.92
Site Preparation and Excavation	\$11,811.36
Load, Screen, and Treat Soils	\$11,651.75
Backfill and Site Restoration	\$1,171.16
Labor, Overhead, and Profit	\$25,394.60
Asphalt	\$17,784.03
Total	\$79,491.82
Output 500 tons	500 tons
Unit Cost Per Ton	\$158.98

Table 3. NSA Mechanicsburg, PA. Demonstration Costs

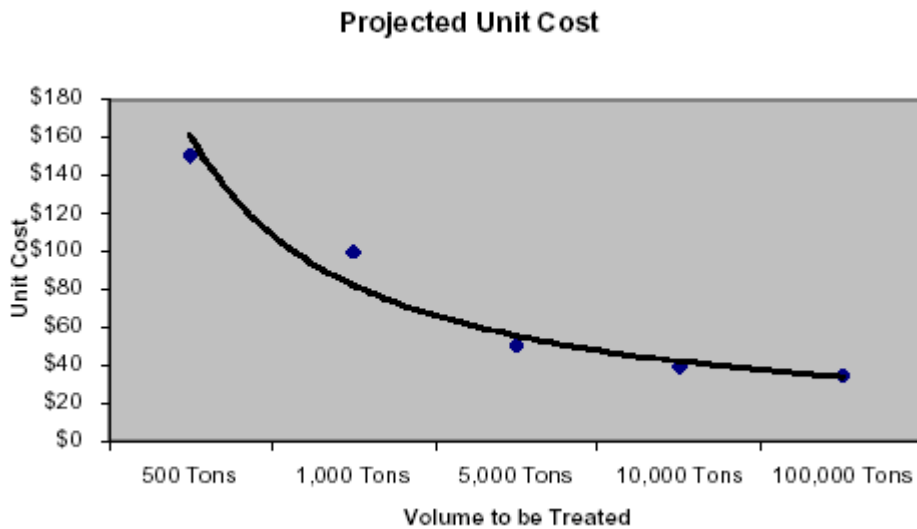


Figure 4. Expected reduction in costs for Encapco Treatment with increasing project scale.

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