Solidification/Stabilization for Site Remediation

An Online Continuing Education Course for Engineers

Course Number: EN-2017

Credit: 2 Hours / 2 PDH / 2 CPD

ABBREVIATIONS AND ACRONYMS

ASR	Annual Status Report
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
cm/s	Centimeters per Second
cy	Cubic Yard
DNAPL	Dense Non-Aqueous Phase Liquid
ETSC	Engineering Technical Support Center
EPRI	Electric Power Research Institute
ROD	EPA Record of Decision
LEED™	Leadership in Energy and Environmental Design
LNAPL	Light Non-Aqueous Phase Liquid
MGP	Manufactured Gas Plant
MCL	Maximum Contaminant Level
µg/L	Micrograms per Liter
mg/kg	Milligrams per Kilogram
NAPL	Non-Aqueous Phase Liquid
NRML	National Risk Management Research Laboratory (U.S. EPA)
NPL	National Priorities List
ORD	Office of Research and Development
PCB(s)	Polychlorinated Biphenyl
PAH(s)	Polycyclic Aromatic Hydrocarbon
PRP	Potential Responsible Party
PCP	Pentachlorophenol
PSI	Pounds per Square Inch
ROD	Record of Decision (CERCLA)
RCRA	Resource Conservation and Recovery Act
RPMs	Remedial Project Managers
S/S	Solidification/Stabilization
STL	Superfund and Technology Liaison
SPLP	Synthetic Precipitation Leaching Procedure
TPR	Technology Performance Review
TCLP	Toxicity Characteristic Leaching Procedure
TSP	Trisodium Phosphate
UCS	Unconfined Compressive Strength
EPA	U.S. Environmental Protection Agency
VOC(s)	Volatile Organic Compound

1.0 Introduction

This course focuses on solidification/stabilization (S/S) treatment and includes its application primarily at CERCLA (Superfund) sites, but also includes a brief discussion of Brownfields, RCRA and other sites. The scope of this course is to provide basic information about S/S treatment. Use of this technology must follow applicable federal, state and local regulations. The course discusses important factors to consider in the selection of S/S treatment, such as treatability studies and S/S specifications to evaluate performance, type of contaminants to be treated, cost considerations, and long-term permanence. The Treatment Technologies for Site Cleanup: Annual Status Report (ASR), 12th Edition, establishes that S/S is among the most frequently used established (where cost and performance is often available) treatment technologies for on- and off-site remedies. According the ASR, S/S was used in 217 Superfund projects from 1982 to 2005.

Several S/S projects, from EPA and the states, were reviewed as part of this course, and most are used as either exhibits or case studies throughout this course. The site-specific case studies illustrate where this technology has been successfully applied and reliability versus where there are limitations. The course is intended to provide assistance to decision makers such as Remedial Project Managers (RPMs), remediation practitioners, researchers, and other interested parties in evaluating S/S as a treatment option for their sites.

Each S/S case study in this course has a brief project description, regulatory status, S/S treatment process that includes binder materials used, and a summary of the performance data. Estimated treatment costs and maintenance activities are also included when available.

This course is not an authoritative or original source of research on S/S treatment. It is intended to briefly describe the S/S process and its potential applicability across multiple sites and conditions. This course cannot be used as the sole basis for determining this technology's applicability to a specific site, because that decision is based on many factors and must be made on a case-by-case basis. Technology expertise must be applied and treatability studies conducted to support a final remedy decision.

2.0 Solidification/Stabilization

S/S is a widely used treatment technology to prevent migration and exposure of contaminants from a contaminated media (i.e. soil, sludge and/or sediments). Solidification refers to a process that binds a contaminated media with a reagent changing its physical properties by increasing the compressive strength, decreasing its permeability and encapsulating the contaminants to form a solid material. Stabilization refers to the process that involves a chemical reaction that reduces the leachability of a waste, so it chemically immobilizes the waste and reduces its solubility; becoming less harmful or less mobile. S/S treatment typically involves mixing a binding agent into the contaminated media or waste. These techniques are done either in-situ, by injecting the binder agent into the contaminated media or ex-situ, by excavating the materials and machine mixing them with the agent.

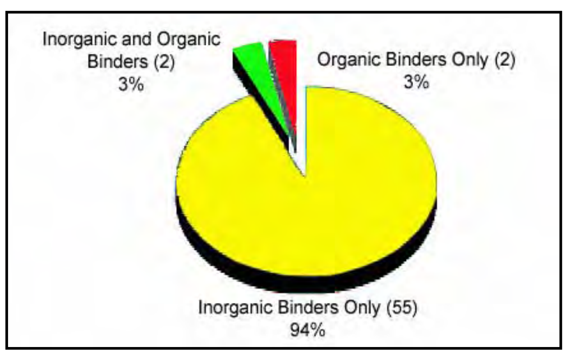

Figure 2-1. Binder Materials Used for Solidification/Stabilization Application

Common types of binder materials used are organic binders that include asphalt, organophilic clay, or activated carbon; and inorganic binders that may include cement, fly ash, lime, phosphate, soluble silicates, or sulfur. Figure 2-1 shows percentage of binder materials used based on input from EPA and State project managers on various S/S applications at Superfund sites in the past. The resulting product from the treatment process is a monolithic block of waste that is either excavated and disposed of in a landfill or re-used on site to support redevelopment.

Another S/S treatment process is vitrification (in-situ or ex-situ). The treatment process uses an electric current, direct-fired kiln, or other heat source to melt soil or other earthen materials at extremely high temperatures (1,600 - 2,000°C or 2,900 - 3,650°F). The treatment process is used to immobilize most inorganics and to destroy organic pollutants by pyrolysis. Inorganic pollutants are incorporated within the vitrified glass and crystalline mass. Water vapors and organic pyrolysis combustion products are captured by an off-gas treatment system for additional processing prior to discharge. Superfund Record of Decision (ROD) data collected from the EPA ASR 12th Edition shows that vitrification has only been selected three times in RODs and construction completed at only one Superfund site as of 2005. The energy requirements and, in cases where ex-situ is used, costs for transportation of materials have precluded use of vitrification as a viable treatment option. Therefore, this course focuses on binder material uses in S/S treatment only.

3.0 Types of Sites and Contaminants Treated By Solidification/Stabilization

There is potential to use S/S under a wide variety of site conditions. Some types of sites at which S/S has been applied or evaluated include: manufacturing gas plants (MGP), wood preserving sites, industrial and municipal landfills, military bases, ammunition plants, waste oil recycling facilities, plating facilities, oil refineries, and battery disposal facilities. Physical and chemical tests must be completed on contaminated material from these sites prior to implementation of S/S treatment. Leaching and extraction tests assist in determining the amount of hazardous contaminants that can leach from the treated waste under a worst-case scenario. Physical tests such as compressive strength can be used to determine absence of free liquids in treated material and also construction properties if treated material is intended for reuse or land disposal. Physical tests of solidified material are also used as indicators of the longevity of the solidification including resistance to freeze/thaw. These tests are described in more detail in Section 4.0.

S/S has been tested and evaluated for its effectiveness in containing and treating a wide array of contaminants, such as metals including lead, arsenic and chromium, and organic contaminants, such as creosote and petroleum products found at sites. For metals, S/S is most often selected for treatment of these contaminants because metals form insoluble compounds when combined with appropriate additives, such as Portland cement. According to the EPA ASR 12th Edition, S/S treatment was selected for source treatment of metals on 180 projects from 1982 to 2005.

In applying S/S for treating organic contaminants, the use of certain materials such as organophilic clay and activated carbon, either as a pretreatment or as additives in cement, can improve contaminant immobilization in the solidified/stabilized wastes. Some organic contaminants have a detrimental effect on the properties of cementitious materials and may not be immobilized by S/S treatment. These organic contaminants should be remediated by some other treatment process, such as thermal or biological processes, prior to performing S/S. Table 3-1 lists S/S treatment effectiveness in treating general contaminant groups.

Table 3-1. Effectiveness of Solidification/Stabilization on General Contaminant Groups for Soil and Sludges

Contaminant Group	Effectiveness
Organic	
Halogenated Volatiles	▲
Non-halogenated Volatiles	▲
Halogenated Semivolatiles	■
Non-halogenated Semivolatiles and Non-volatiles	■
Polychlorinated Biphenyls	■
Pesticides	■
Dioxins/Furans	●
Inorganic	
Non-volatile Metals	■
Radioactive Materials	■

■ = Demonstrated Effectiveness ▲ = No Expected Effectiveness ● = Potential Effectiveness

Superfund S/S Application

S/S is frequently selected as a source control treatment option at EPA Superfund remediation sites. Based on Superfund RODs from FY 1982 through FY 2005, 23 percent of selected source control remedies for these sites included the use of S/S (see Figure 3-1). For S/S, 18 percent of these source control projects were ex-situ treatment with only 5 percent being in-situ treatment. EPA has also identified S/S treatment as Best Demonstrated Available Treatment Technology for at least 50 commonly produced Resource Conservation and Recovery Act (RCRA) hazardous wastes.

Exhibit 3-1 provides an example of a successful S/S remedy at the Peak Oil Superfund Site in Tampa, Florida.

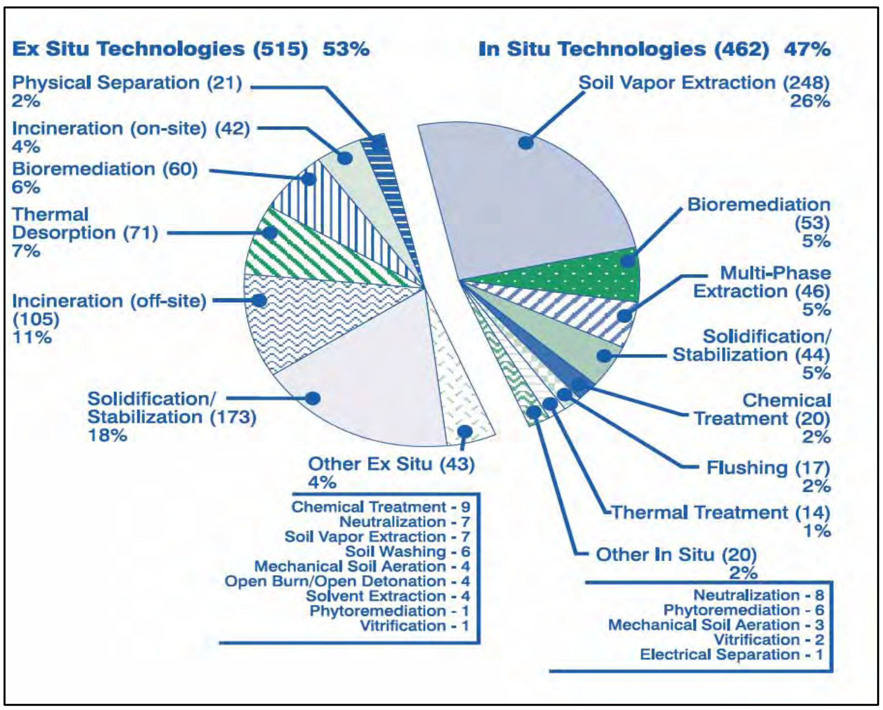

Figure 3-1. Source Control Treatment Technologies (FY 1982-2005)

Exhibit 3-1. Peak Oil Superfund Site in Tampa, Florida

Figure 3-2. Ex-Situu Soil
Peak Oil Site

The Peak Oil Superfund site a former waste oil recycling plant site, covered 15.5 acres and soil was contaminated with waste oil products, including polychlorinated biphenyls (PCBs), lead, and bis (2-ethylhexyl) phthalate. As a result of a previous remediation attempt (infrared heat treatment), a stockpile of contaminated ash mixed with soil was also present. The underlying lithology was made up of variable drift and included sand, silt, clay, and peat. This area also had a shallow water table with a low hydraulic gradient to the west.

The treatment meth... involved excavation of ... the void to a height of 8 to 12 ... clean soil. The excavated oil- ...nded together and treated ...anules to further immobilize ...eened and fed through a ... cement binder agent (see ... of material was treated.

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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Brownfields Solidifica...

One of the more optima... ...chnology for remediation of contaminated industr... ...f Brownfields sites across the country. The treated ... ...elopment efforts since S/S treatment can impro...

Exhibit 3-2 provides an e... ...S treatment to remediate contamination at a forme... ...vard at the EPA-sponsored Brownfields 20... ...U.S. Green Building Council's Leadership in E...

Exhibit 3-2. Kendall Sq... ...Cambridge, Massachusetts

Kendall Square is a former MGP site that covered 10-acres in East Cambridge, Massachusetts. Byproducts from the MGP operations led to soil impacted with coal tar and petroleum residues. As a temporary cleanup remedy, a previous owner of the property capped the subsurface contamination with a parking lot, which remained in place for about 30 years. Revitalization of the area surrounding the property made it attractive for redevelopment. The results of an environmental investigation found 4 acres of soil impacted with polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs), from 0 to 20 feet below grade; and a 3-acre non-aqueous phase liquid (NAPL) plume that consisted of: dense non-aqueous phase liquid (DNAPL) present at the groundwater/clay interface about 20 feet below grade and light non-aqueous phase liquid (LNAPL) on the groundwater surface about 10 feet below grade.