Solidification/Stabilization treatment technology for contaminated sites in the United States and Canada

Mass Stabilisation Conference

Lahti, Finland  April 23, 2015

Charles M. Wilk
ALLU Group Incorporated
U.S.A.
What is S/S Treatment for Remediation?

Involves mixing a binding/reaction agent(s) into contaminated media such as soil, sediment, sludge or industrial waste.

S/S treatment protects human health and the environment by immobilizing hazardous constituents within treated material.

Physical (solidification) and chemical (stabilization) changes to the treated material.

Mobility Reduction Terms: Stabilisation (UK), Inertage (France), Immobilization (EU).
State of Remediation Technologies
Superfund Remedy Report
FOURTEENTH EDITION
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Figure 10: Trends in Source Decision Documents Selecting In Situ Treatment (FY 2005-2011)

- Number of source decision documents = 645.
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Types of Sites Applied

- Wood Preserving Sites
- Herbicide and Pesticide Sites
- Oil Refinery Sludge Lagoons
- Manufactured Gas Plants
- Sediment including PCB
- Metal Refining, Smelting, Plating, Recycling
- Residual Ash
Laboratory Formulation

Bench-scale mix design and testing utilizes high mixing shear for optimum results.
S/S Agents

Portland cement, Cement kiln dust
Fly ash e.g. Class F and C (pozzolanic fly ashes)
Lime e.g. quicklime, hydrated lime, lime kiln dust
Slag e.g. ground granulated blast furnace slag
Organoclay®
EnviroBlend®
Bentonite clay
Activated carbon
Cement-based proprietary mixtures
Silicate, phosphate, and sulfate
e.g. triple super phosphate
Sample Effects of Agents

- Mass strength development:
  - Cements, slags, fly ashes
- Mass hydraulic conductivity reduction:
  - Bentonite, cements, slags,
- Encapsulation: strength and lower hyd. cond.
- Sorption of hazardous constituents:
  - Activated carbon, organophilic clay
- Chemical changes to hazardous constituents
  - pH: hydroxides
  - Compounding, sulphates
  - Oxidation: insitu chemical oxidation: permanganates
  - Reducing: “hex” Cr to trivalent Cr
Physical Tests

Hydraulic Conductivity/ Permeability
1X10^{-5} to 1X10^{-7} cm/sec
“Two orders of magnitude lower than surround soil”

Unconfined Compressive Strength- 0.34 MPa (50 psi)

Paint Filter Test (PFT) – free liquids
Freeze-Thaw & Wet-Dry Durability
Chemical Testing

Synthetic Precipitation Leaching Procedure (SPLP)

Toxicity Characteristic Leaching Procedure (TCLP)

Multiple Extraction Procedure

Equilibrium Leach

ANS/ANSI 16.1

Dynamic Leach

LEAF
Bench-Scale to Full-Scale

VS

Mixing Energy & Shear

25-100 RPM
12000 Nm (9000 ft-lb) torque per drum.
Provides Mixing Energy and Shear

Folding Mixing Action dependent on Operator’s “Stroke”
Auger Mixing

Crane-mounted augers efficient mixing depths begin at 6 meters (20 ft) and deeper. Crane’s limited range of motion.
Road Reclaimer / Soil Stabilizer

Limited mixing depth: 500 mm (20 in)
Bucket Mixing  Injector Rake

"Folding Action" Mixing Methods
Excavator-mounted: Efficient mixing to depths of 7 meter (23 ft). Articulated arm of excavator lessens repositioning of equipment.
Binding Agent Pricing

- Priced by transportation costs:
  - Industrial waste/byproducts, finely divided materials available on site, e.g. spent fullers earth, ash

- Priced per ton:
  - Common construction materials:
    - portland cement, blended cements, Class C or F fly ash, GGBFS, lime.

- Priced per pound:
  - Specialized materials, sorptive, reactive, or compounding
    - Carbons, organophilic clays, oxidizers, reducers
Efficient Use of Binders Matters

Most of the cost in a mass stabilization project comes from the binder, which represents about **50-70 % of the total project cost**.

Efficiencies (Cost Savings) are improved by:

- Thorough mixing (mixing shear & energy) resulting in intimate contact of binder and subject material.
- Introduction of binder at mixing point.
- Locating and metering of binder to avoid under-dose and overdose.
- Use of dry binders in wet materials to conserve drying capacity of binders.
North American Projects
Solidification: Ashtabula Harbor, OH

Dredge and S/S treat 120,000 CY (92,000 m$^3$) of contaminated sediment.

Placement of S/S treated dredge into Elkem 5C Pond, a 3.6 hectare (9 acre) former settling pond. Additional material needed to facilitate closure of pond.
Ashtabula Harbor: Elkem 5C Pond

- Solidification of existing contents 153,000 m³ (200,000 CY)

Calciment (binder) added dry 20% by weight. UCS goals range from 0.05 to 0.07 MPa (1,000 psf to 1,500 psf). Unconsolidated shear strength goal of 0.08 MPa (1,250 psf). Mixing depths variable – 1.5 to 6 m (5 - 20 ft)
AWI Project

- Insitu S/S of 36,000 m³ (47,000 CY) creosote- and pentachlorophenol-impacted soils
- Treatment depths ranging from 2.4 to 8.2 m (8-17 ft)
- Performance standard
  - >0.34MPa (50 psi) UCS
  - <4 X 10⁻⁶ cm/sec
Atlantic Wood Industries
Portsmouth, Virginia

Performance Standard:
• 50 psi (0.34 MPa) UCS
• $4 \times 10^{-6}$ cm/s hydraulic conductivity

Three-part mix: portland cement, slag, and organophilic clay.
AWI Mix Design

- 23,500 m³ (30,500 CY) treated with:
  - 8% portland cement/slag and
  - 1% organophilic clay
- 11,600 m³ (15,200 CY) treated with:
  - 8% portland cement/slag and
  - 3% organophilic clay
- Cement/clay mixture injected as slurry and mixed by ALLU Power Mixer.
Insitu Chemical Oxidation: WV Terminals Site, Kenova, WV

Chemical Oxidation and Solidification Treatment of petroleum-impacted soil. Contaminants as non aqueous phase liquid (NAPL) and metals.
ISCO at WV Terminals Site

Excavation and set aside of top 1.2 meter (4 feet) of soil. Loosening of soil 1.2 – 2.4 meters (4-8 feet) below grade.

ALLU Power Mixer used to mix oxidizer and binder into soil 8,400 m³ (11,000 CY) treated.
ISCO at WV Terminals Site

Mix Design: Sodium Persulfate (oxidizer) 5% by weight of soil
Portland Cement (binder) 10% by weight of soil
Columbus Manufactured Gas Plant
Subsurface Site Containment Walls

- 25% Cement addition

Solidification of Contaminated Soil Sludges

- 10% Cement addition
Inclusions

Core Samples

Former MGP Sites
Evaluation of the Effectiveness of In-Situ Solidification/Stabilization at Georgia Manufactured Gas Plant (MGP) Site

1009095

Final Report, September 2003

EPRI Project Manager
A. Coleman
Leachability Testing
Groundwater Modeling
Groundwater Monitoring

S/S is an Effective, Long-Term Solution
Sydney Tar Ponds, Sydney, NS
Canadian Forces Base Esquimalt, Victoria Island, BC
Contact

Charles Wilk
Manager, Stabilization and Remediation Applications

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