Stabilization and Beneficial Use of Contaminated Sediments Applying Mobile Pneumatic Flow Tube Mixing for a Circular Economy

11th International SedNet Conference
3-5 April 2019
Dubrovnik Croatia

E.A. Stern, R. Miskewitz, A. Maher\(^2\), A. Kovalik, M. Kitazume\(^3\), D. Yang\(^4\) and A. Ringen\(^4\)

\(^2\)Rutgers University
\(^3\)Tokyo Institute of Technology
\(^4\)JAFEC USA
Thesis:

- It’s about stabilization of contaminated sediments but more about the Messenger / Delivery System
- Minimizing long distance transport to landfills (unrenewable resources – GHG/LCA)
- Reverse Engineering to the Vision Proposition with an Innovative Process and Outcome
  - Apply Beneficial Use
  - To be integrated into Sustainability Metrics in Remediation Remedy Selection
    - Difficult to do after the remedy is decided
- Barge mounted system that allows project/program flexibility not realized especially in complex urban systems
  - Develop platform / systems engineering to support PFTM
Advancements: Eco-Industrial/Circular Economy Beneficial Use – 1\textsuperscript{st} Generation

- Waste of one process becomes the resource for another: (LCA) / Sustainability Metrics
- End-of-pipe view to a market-led substitution:
  - Zero energy systems
  - Material substitution
  - Reduced Raw Material Consumption
  - Functional Economy (jobs)

CEAMaS – NL, UK, Ireland, Germany, Belgium, FR
Cement-Lock\textsuperscript{tm} – Volcano Partners, LLC
Envisan – Jan Du Nul - France
TREVI/3V Green Eagle Sediment Washing – Italy
SETARMS - France
[Urban] Regional Sediment Management (USM) Contaminated Sediment Systems

- **Sustainability / Resilience**
  - **Eco-psychology**
    - Behavioral understanding of moving forward
      - Open to Change - Innovation
      - Urban – City / Port Environment / infrastructure
      - Leadership
      - Stakeholders / Partners (PRPs)
      - Different brain wiring – short vs. long-term horizons
        - community – political - business interests

- **Integrated Sediment Management**
  - **Hybrids – Holistic – Innovative Technology Approaches**
    - Multi Contaminants / Multi Media / Beneficial Use
  - Regional Sediment Management – **SOURCE CONTROL**
  - Adaptive Management
  - Linkage of Engineering with Societal Goals

- **Net Environmental Benefit - Vision**
  - Sediments replacing non-renewable resources (economic re-development)
    - Ecosystem – Industrial Approach
    - Local Economy
    - Reverse Engineering the Remedy (Sustainability Metrics)
2nd Generation:

✓ Benefits are accrued by mutually realizing the “vision” of the pre and post remediated community as well as the industrial investor - achieving revitalization (both environmentally and economically) by strengthening of the built environment.

Reverse Engineering = Circular Economy for Beneficial Use of Sediments (technology driven)
GOWANUS CANAL – Brooklyn, New York
Challenges of Remediation in a Urban Sediment Management Circular Economy - 4D

- TIME
- SPACE
- DISTANCE

➢ INNOVATION
  ▪ 0th Dimension
    ▪ PFTM
    ▪ $$ €€$

Don’t do this
Sediment Disposal Sites (landfills/incineration) – $$ US / €€ EU

Global Multiple Waste Management
- sediments (Haz) - sewage sludge - MSW

Legend
- INCINERATOR FACILITY
- LANDFILL FACILITY

CAD
CDF
NIMBY
Environmental Justice
Solidification/stabilization (S/S) is a well-established strategy for the treatment, dewatering and improvement of contaminated sediments, soils and several waste materials.

S/S is a commonly used treatment technology in the US and around the world for a wide range of remediation projects including management of radioactive and hazardous wastes, and contaminated site remediation and Brownfield redevelopment.

The US Environmental Protection Agency has completed several remedial actions using S/S as the primary treatment technology. It has been shown to be effective for a wide variety of organic and inorganic contaminants found in contaminated sediment, soil, and other waste types.

The most successful treatment strategy is the S/S with Portland cement and beneficial use at upland sites and/or efficient trans-loading shipments. To date, approximately 23 million cubic meters of stabilized dredged materials have been applied at a variety of placement sites throughout New Jersey.
Treatment and Materials Science Research/Applied Programs Working Towards a Sediment Circular Economy Beneficial Use

- Sedi.Port.Sil
- CEAMaS
- SETARMS
- SEDILAB
- EcoSed
- GeDSET
- Sedimateriaux Approach

- New York/New Jersey Harbor Sediment Decontamination Program (USEPA/NJDOT/Brookhaven National Lab)
  - Changing perception of sediments as a waste to a sustainable resource

- 2019 CEDA Position Paper on the Beneficial Use of Contaminated Sediments
- Global Case Studies
Challenges with In-Barge S/S

- Debris
- Uneven Mixing
- One mix for entire barge
- Often over/under design mix
- Dust and Air Emissions
Bellingham, Washington USA
Squalicum Harbor

EIS Associates, NY/NJ Harbor

Dredged Material Cement Pug Mill / Geotube Operations (large footprint)

Boskalis – Membrane Dewatering Lower Passaic River, New Jersey

Pneumatic Flow Tube Mixing Operations (small footprint)
PFTM Background

Pneumatic Flow Tube Mixing (PFTM)

- Developed in Japan in early 2000 for large scale reclamation projects using fine silty clay sediments
- Many successful examples including reclamation works for Tokyo (Haneda-2010) and Central Japan (Chubu-2005) Airport Projects.

“Soft sediment is broken into “plugs” by compressed air. Plugs reduce pipe surface friction easing flow. During transport cement and clay are mixed by the turbulent flow within the ‘plug’.” - Kitazume 2002
Internal controls measures water content and binder dosing real time

Feedback Loop System

Onsite Cement Silos

Slurry Plant

Water Tank

Generator

PFTM Tool

Mixing and Treated Sediment Transport Pipes

Treated Sediment

Air Compressors

Gamma Ray Densimeter

Check Valve

Sediment Pump

Screened Sediment Through Transport Pipes

Vibratory Grizzly Screener

Loader

Generator

PFTM Process Flow (Detailed)
Haneda Airport Reclamation 2010

Cement treated soil with pneumatic flow mixing method
Dredged clay + Cement
Approx. 5,400,000 m³
PFTM Process Flow – 7.6K m³/Day (Japan)

Deposition spreader (placement)

PFTM Platform (stabilizing agents /supplier barge)

Dredge Screen Barge
Pneumatic Flow Tube Mixer (PFTM) 1\textsuperscript{st} Generation NY/NJ Harbor (2015)
Pumped up to 1 km
Further with booster
Amended dredged material pumped from PFTM

Hardened/cured dredged material as structural fill in one day
PFTM Applications and Placement Options

- **Environmental**
  - Solidification/Stabilization of contaminated soft sediments *(no dewatering or H₂O Treatment)*
    - Remediation: materials handling transport alternatives – **direct pumping upland or sub-aqueous capping / habitat restoration**
      - *Superfund* *(complex footprints and infrastructure)*
      - *MGP and Utilities Sites*
  - Brownfields
  - Upland beneficial use of unsuitable dredged materials not meeting aquatic placement criteria *(open H₂O)*
  - Coastal Restoration
    - Coal Combustion Residues *(CCR)*
    - Sediments loads behind Dams
  - Structural
    - Bulkhead backfills *(Gowanus Canal, Newtown Creek, New York)*
      - Reduction of lateral earth pressures
    - Berm construction for flood control
    - Trench filling
    - Structural Caps – brownfields
    - Structural and non-structural fills
    - Shallow improvement
    - Liquefaction mitigation and improvement of dynamic response
    - Port Expansion *(Sweden, Norway, Ireland, UK)*
  - **Allows Project Flexibility in Design and Construction Options**

- Structural
PFTM Placement Options (continued)

- PFTM system is *barge mounted* and can deploy to any coastal site / Can be operated *land side* and work interior (lagoon or dock)
  - Anchored to a Regional Dredged Material Manufacturing Facility (RDMMF)
  - Operating directly adjacent to project site and pump upland for beneficial use / landfill closure, brownfield redevelopment, bulkhead stabilization

- Integrates contaminated sediment placement with fill required at many coastal sites
  - Raising/elevation for flood protection
  - Capping / landfills (interior or coastal) via pumping

- Stabilized material is designed to meet or exceed geotechnical end-use specific (regulatory) criteria
  - Geotechnical
  - Environmental

- Research for alternative amendments and binders

➢ Can be pumped under bridges and/or challenging urban infrastructure to a trans-loading facility or used internally for BU / structure - habitat
Pneumatic Flow Tube Mixer (PFTM2000) – MOBILE SEDIMENT ENGINEERING SYSTEM (MOSES)
Port of Coeymans, New York Hudson River Assembly / Carver Marine (2017)
Vibratory Grizzly Screener with Debris Chutes / Collectors into Roll-offs
State of the Art Debris Screening - Hopper Charging Deck and Two Stage Vibratory Screening
Dual Sediment Slurry Reservoirs with Outlet into Eddy Pump to PFTM
Pneumatic Flow Tube Mixer (PFTM) – 1530 m³/day [2000 yd³]

Untreated Sediment In

Stabilized Sediment Out

Compressed Air In

Cement Slurry In
Pier PFTM Layout
3D PFTM Barge Design – MOSES (MOBILE SEDIMENT ENGINEERING SYSTEM)
PFTM Attributes to Drive a Circular Economy in Urban Sediment Management Systems

- Mixing and transport in a closed pipe system
  - Transport with air allows pumping amended sediments with up to 1Km / 3000 ft from processing site (simplifies supporting and staging areas needed)
- No water or air discharge (no dependence on geotubes, water treatment or mechanical presses)
  - No dewatering area; reduces the footprint needed
  - No waste water treatment plant needed
- Sustainable approach to remediation sediment management (less water and energy consumption, beneficial use applicability)
- Barge or land mounted equipment (flexible) with a high processing to operating footprint
  - PFTM 500 / 46 m³ (60) CY/hr
  - PFTM 2000 / 190 m³ (250) CY/hr
- Structural flowable fill output that can be directed
  - Based on over 20 years of stabilization work performed in Japan and demonstrated for NJDOT in 2015
- Shortened schedule
- Lower Costs
  - Smaller land footprint (if any) – barge mounted (fixed) or modular barges, land skid system
  - Material is ready for trucking and/or or being barged at the end of the process to a trans-loading facility
  - Material can be used for many different types of beneficial use right away
  - Material is stabilized and can be designed to meet or exceed client / regulatory specific criteria (treatability testing)
Connecticut Marina Dredging / Upland Remediation
Beneficial Use Integration
Conceptual Layout for PFTM Barge Mounted System and Beneficial Use of Sediment at Stratford Connecticut Remediation Site

US Army Tank Engine Plant
Sediment Immortality
Contact Information:
Tipping Point Resources Group, LLC

Eric A. Stern
eric@tprgllc.com
201.247.3281

www.tprgllc.com
Upland Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth