SUSTAINABLE SEDIMENT SOLUTIONS: STABILIZATION OF CONTAMINATED SEDIMENT

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WHAT IS STABILIZATION OF SEDIMENT?

Transform sediment characteristics by mixing with a pozzolanic material and other additives

- Mitigate hazardous characteristics
- Reduce mobility or leachability of contaminants
- Improve structural characteristics for reuse
- Increase medium stability
- Improve handling characteristics prior to disposal or further treatment

Focus of this presentation is on large scale bulk mixing that can be performed on sediments in place or on dredged materials
WHY STABILIZATION OF SEDIMENT?

- Sustainability and Circular Economy Benefits
  - Minimize need for landfill or off-shore disposal space
  - Minimize sediment transportation requirements
  - Provide opportunities to use dredge material beneficially
    or
  - Reduce need for dredging
- Technology is widely used, accepted, and understood for environmental and geotechnical improvement
- Can stand alone or augment other sediment management technologies
- May reduce cost
STABILIZATION OR SOLIDIFICATION?

- **Solidification**: Physical transformation from reaction with reagents.
  - Contaminated materials are encapsulated “physically trapped”
  - Reduction of permeability
  - Increased compressive strength and media durability

- **Stabilization**: Chemical reaction between reagents and media
  - Reduction in leachability of targeted contaminants
  - Transformation of targeted contaminants
  - Reduction of solubility of contaminants
DESIRED ENDPOINTS

Performance Requirements are quantifiable metrics that demonstrate you can meet project goal

- Typical Performance Requirements
  - Unconfined Compressive Strength (UCS)
  - Hydraulic Conductivity (HC) lower than surrounding sediment
  - Leachability - Contaminant reduction?
- Define bright line or build in some flexibility
  - Average with floor/ceiling value
  - Different criteria for different areas and future uses
STABILIZATION OF POST DREDGED MATERIALS

OR

STABILIZATION OF SEDIMENTS IN PLACE
POST DREDGE

- Treat Dredge Soils in upland area for beneficial reuse on-site or off-site
- Reduce environmental footprint – less landfill disposal
- Minimizes re-handling
- Requires large upland area
- May reduce sediment dewatering efforts
JÄTKÄSAARI HELSINKI

- Urban renewal project
- Historic port to modern residential area
- Ongoing 2011 to present
- Dredging contaminated sediment, basin stabilization
- Produce usable construction materials
LABORATORY MIX EVALUATION

- Explore promising mixtures
- Exploit industrial by-products?
- Chemical compatibility and leaching
- Strength targets assurance
- Optimum cost-benefit determination
## Binder Costs, Some Unit Price Calculations

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Quality</th>
<th>Relative Binder Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce</td>
<td>Poor</td>
<td>60%</td>
</tr>
<tr>
<td>50 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce</td>
<td>Good</td>
<td>100%</td>
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<tr>
<td>80 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce+FA</td>
<td>Very good</td>
<td>70%</td>
</tr>
<tr>
<td>50+150 kg/m³</td>
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</tbody>
</table>
# LEACHING TEST RESULTS
## WEST HARBOUR PHASE III

<table>
<thead>
<tr>
<th>Element</th>
<th>Limit value [mg/m²]*</th>
<th>Test results** 64 d [mg/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic, As</td>
<td>58</td>
<td>0.4 – 0.6</td>
</tr>
<tr>
<td>Barium, Ba</td>
<td>2800</td>
<td>4.0 – 9.3</td>
</tr>
<tr>
<td>Cadmium, Cd</td>
<td>2,1</td>
<td>0.04 – 0.06</td>
</tr>
<tr>
<td>Cobalt, Co</td>
<td>280</td>
<td>0.21 – 0.25</td>
</tr>
<tr>
<td>Copper, Cu</td>
<td>250</td>
<td>0.7 – 3.3</td>
</tr>
<tr>
<td>Mercury, Hg</td>
<td>1,6</td>
<td>0.04 – 0.14</td>
</tr>
<tr>
<td>Molybdenum, Mo</td>
<td>70</td>
<td>3.6 – 22.9</td>
</tr>
<tr>
<td>Nickel, Ni</td>
<td>270</td>
<td>0.4 – 2.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Limit value [mg/m²]*</th>
<th>Test results** 64 d [mg/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead, Pb</td>
<td>210</td>
<td>0.2 – 0.3</td>
</tr>
<tr>
<td>Antimony, Sb</td>
<td>36</td>
<td>0.8 – 16.8</td>
</tr>
<tr>
<td>Selenium, Se</td>
<td>14</td>
<td>0.5 – 1.9</td>
</tr>
<tr>
<td>Tin, Sn</td>
<td>280</td>
<td>1.5 – 6.5</td>
</tr>
<tr>
<td>Vanadinium V</td>
<td>700</td>
<td>0.7 – 4.7</td>
</tr>
<tr>
<td>Zinc, Zn</td>
<td>330</td>
<td>2.4 – 4.0</td>
</tr>
<tr>
<td>Fluoride, F</td>
<td>2800</td>
<td>105 - 124</td>
</tr>
</tbody>
</table>

**Limit values** presented in the environmental permit application of Sepänmäki noise barrier.

Modified test according to standard NEN 7375:2004
Full scale implementation!

- Pilot testing proves laboratory results
- Quality control is key to success
- Designer should be involved
  - On site modifications due to changing conditions
  - Lessons learned for future port work and site
MASS STABILIZATION IN JÄTKÄSAARI

Binders:
- Cement
- Lime cement
- Cement and fly ash
- Oil shale ash

DIFFERENT BINDER RECIPES
SEPÄNMÄKI NOISE BARRIER

MASS STABILIZED SURPLUS CLAY FROM WEST HARBOUR PHASE III (CONSTRUCTION IN 2016-2017)

SEPÄNMÄKI NOISE BARRIER,
DESIGNED H = 5-13 M
SEPÄNMÄKI NOISE BARRIER, HELSINKI

- Construction from April to October 2016
- 2893 truckloads of stabilized sediment (distance from West Harbour 12 km)
- A total of 29540 cubic meters transported and placed
IN PLACE

• Treat sediment in place
• Minimize short term impacts by reducing remediation timeframe
• Minimize infrastructure upgrades and protect existing bulkheads and other structures
• Reduce environmental footprint – less trucks, less landfill disposal
• Resist erosion & scour
• Improve habitat
IN-PLACE
IN PLACE
GROUNDWATER FLOW IMPACTS

Stabilized Sediment

Untreated Sediment

Groundwater Flow
POST IN SITU STABILIZATION CONDITIONS

- Wisconsin, USA
- MGP Sourcee Material impacted soils
- 1.6 hectare solidification effort
- 61,000 m$^3$ of impacted soils
- 60 cm of clean fill cover over solidified soil
POST ISS HABITAT EVALUATION

• Solidified area now submerged due to rising Great Lakes water levels
• Clean backfill resembles aquatic environment
• Assessed post ISS Benthic community
POST STABILIZATION HABITAT RESULTS

Concentrations of sediment samples collected from ISS area not expected to present risk to benthic invertebrates

Benthic invertebrate community similar between ISS and reference areas

Benthic community at ISS area indicative of earlier succession stage relative to reference area

Benthic community metrics at ISS area supportive of remedial technology in aquatic environments
THANK YOU!