IN SITU MASS STABILIZATION

Stabilization of Contaminated Sediment for Re-use at the Port of Helsinki and Other Finland Sites

Michael Mengelt

Ramboll Bright ideas. Sustainable change.
IN SITU MASS STABILIZATION

Stabilization of Contaminated Sediment for Re-use at the Port of Helsinki and Other Finland Sites

Michael Mengelt
MASS STABILIZATION (ISS)

- Dry mixing method
- *In situ* or *ex situ* stabilization
- Cost from 30–100 euro/m³
  - Mixing cost 10 euro/m³
  - Binder cost is the remainder of the price!
DREDGED SOIL MANAGEMENT

Prefeasibility

Decision

Design, optimize, test

Decision

Pilot project

Decision

Full scale stabilization

Geotechnical properties

Environment

Cost efficiency
LABORATORY MIX EVALUATION

- Explore promising mixtures
- Exploit industrial by-products?
- Hydraulic conductivity
- Chemical compatibility and leaching
- Strength targets assurance
- Optimum cost-benefit determination
STABILIZATION CONSTRUCTION PHASE

- 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
JÄTKÄSAARI HELSINKI

- Urban renewal project
- Historic port to modern residential area
- Ongoing 2011 to present
- Dredging contaminated sediment, basin stabilization
- Produce usable construction materials
JÄTKÄSAARI HARBOUR
MAY 2013
MASS STABILIZATION IN JÄTKÄSAARI

Binders:
- Cement
- Lime cement
- Cement and fly ash
- Cement and bio-reactive fly ash
- Oil shale ash
COLUMN SOUNDING TEST RESULTS
SOME EXAMPLES OF ASHES AS A BINDER, JÄTKÄSAARI

<table>
<thead>
<tr>
<th>Quality</th>
<th>Shear strength (kPa)</th>
<th>Depth (m)</th>
<th>Binders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
<td>Ce 50 kg/m³</td>
<td>I / 2011 Ce</td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td>Ce 80 kg/m³</td>
<td>II / 2012 Ce, Ce+FA</td>
</tr>
<tr>
<td>Very good</td>
<td></td>
<td>Ce+FA 50+150 kg/m³</td>
<td>III / 2014 Ce+FA, LC+FA, Ce/LC+FA+FGD, OSA5, OSA8</td>
</tr>
</tbody>
</table>

"Overshoots target"

OSA5 (Oil Shale Ash) 150 kg/m³
## 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>Ce</td>
<td>Good</td>
<td>100%</td>
</tr>
<tr>
<td>Ce+FA</td>
<td>Very good</td>
<td>70%</td>
</tr>
<tr>
<td>Ce+FA (reactive bio fly ash)</td>
<td>Good</td>
<td>20%</td>
</tr>
</tbody>
</table>

- Ce: 50 kg/m³
- Ce: 80 kg/m³
- Ce+FA: 50+150 kg/m³
- Ce+FA (reactive bio fly ash): 200 kg/m³
# WATER PERMEABILITY LABORATORY TESTS RESULTS

## WEST HARBOUR PHASE III

<table>
<thead>
<tr>
<th>Binder</th>
<th>Binder amount [kg/m³]</th>
<th>Water permeability [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce+FA</td>
<td>50+150</td>
<td>1,1 × 10⁻⁹</td>
</tr>
<tr>
<td>Ce+FA</td>
<td>50+150</td>
<td>7,4 × 10⁻⁹</td>
</tr>
<tr>
<td>Ce+FA</td>
<td>50+150</td>
<td>1,7 × 10⁻⁹</td>
</tr>
<tr>
<td>Ce+FA+FGD</td>
<td>50+150</td>
<td>1,1 × 10⁻⁹</td>
</tr>
<tr>
<td>LC 3:7+FA</td>
<td>50+150</td>
<td>1,2 × 10⁻⁹</td>
</tr>
<tr>
<td>LC 3:7+FA+FGD</td>
<td>50+75+75</td>
<td>1,1 × 10⁻⁹</td>
</tr>
<tr>
<td>OSA8</td>
<td>150</td>
<td>8,2 × 10⁻⁹</td>
</tr>
</tbody>
</table>

**Binders:**
- Ce = Cement
- FA = Fly ash
- LC = Lime + Cement 1:1
- FGD = Flue gas desulphurisation agent
- OSA5, OSA8 = Oil Shale ash

**Limit values** presented in the environmental permit application of Sepänmäki noise barrier, max. 1 × 10⁻⁸ m/s.

10⁻⁸ m/s > 1...8 × 10⁻⁹ m/s
## 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>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>Vanadium, 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 NBN 7375:2004
SEPÄNMÄKI NOISE BARRIER

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

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

RAMBÖLL
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 (39,400 cu. Yd) transported and placed
SEPÄNMÄKI NOISE BARRIER INVESTIGATIONS
OTHER RE-USE EXAMPLES IN THE HELSINKI REGION

• Landfill cap structure and intermediate storage area in Vuosaari, Helsinki, **120 000 m³**, 2010-2015
• Alakivenpuisto park, Helsinki, **34 000 m³**, 2014-2015
• Road noise wall, Helsinki, **29 000 m³**, 2016
• Hyväntoivonpuisto park, Jätkäsaari, Helsinki, **5000 m³**, 2011
• Ida Aalberg park, Helsinki, **100 m³**, 2013
THANK YOU!