SMOCS
SUSTAINABLE MANAGEMENT OF CONTAMINATED SEDIMENTS

Quality Assurance/ Quality Control (QA/QC)

Project acronym:	**SMOCS**
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Introduction

It has shown to be important to have Quality Assurance/Quality Control (QA/QC) to get the required (designed) quality throughout the project. Often it is mandatory. The QA/QC should be presented in a plan/programme.

The stabilisation/solidification method is an effective solution to treat dredged contaminated sediments by mixing binder into the dredged sediments. Successful implementation of this process by mass stabilization technology or process stabilisation technology includes the quality assurance and quality control (QA/QC) during all project stages: investigation of sediments, planning, detailed design, dredging and construction, operation and maintenance. The QA/QC is presented in a plan/program of its activities, including the organisation of the work with responsibilities and time schedule.

Preparation of quality control plan/programme

The content of quality control plan can be divided into separate stages according to the project objectives and foreseen processes. Each stage should clearly define the steps of quality assurance including a flow diagram with the internal position of, and interaction with, program and project managers, project coordinator and regulatory officers.

I. Plan for a design and construction process

This part of the programme includes ***environmental*** and ***geotechnical*** issues, which are usually coupled to checklists with attached forms and document of records.

Planning of environmental activities

Environmental activities to which QA/QC programs may be coupled include:

- Field data collection and sampling
- Laboratory analysis and reporting
- Evaluation of data and assessment
- Project reporting and documentation

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Examples on what to include in an environmental QA/QC program for laboratory and/or field activities are:

- *QA program organisation flow chart / diagram*

This part of the programme may be divided in separate chapters, each focusing on a specific task (e.g. flow chart for laboratory testing, flow chart for sampling and transport, flow chart for sample analysis).

- Data quality objectives for accuracy and completeness
- Chain-of-custody documents/records
- Field tracking report
- Laboratory tracking report
- Sample labelling
- Station location log
- System audit checklist
- Corrective action checklist

An environmental control program may be divided in sub chapters each focusing on a specific task. Each sub chapter may be related to each other.

QA/QC in an environmental control program shall also include the different products to be used, e.g. the binder components (cement, slag, ash etc.) at s/s-method.

Planning of geotechnical activities

Geotechnical issues to which QA/QC programs may be coupled include:

- design (incl. derived parameters and computer programmes used)
- field data collection and sampling
- laboratory analysis and reporting
- evaluation of data and assessment
- project reporting and documentation

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As an example for beneficial use of s/s-treated dredged sediments the parameters compressive strength, permeability and compression properties of the treated sediments shall be studied at least two times after treatment, but preferably at three times. Enough testing shall be performed to get a good picture of the values of the studied parameters incl. the change with time. Regarding the behaviour of the structure (e.g. a quay with treated sediments as backfill), settlements (vertical and horizontal movements) and/or deformations with time (creep) should also be studied.

II. Plan for the execution procedure

This part of the programme includes following aspects:

- Type of dredging equipment
- Type of dredging method
- Water content of dredged sediments
- Transport of dredged sediments
- Treatment of dredged sediments (equipment, procedure, in-coming binder components, binder recipe follow-up, out-coming treated sediments, consideration of variation in water content of in-coming sediments)
- Placement of dredged (possibly treated) sediment

III. Plan for the operation and maintenance

Example: QA/QC programme for the field test in Port of Kokkola

Quality control before dredging

1. Field data collection and laboratory testing:

- Sediment sampling (diving)
- Determination of sediment geotechnical properties (water content, bulk density, loss of ignition, pH, grain size distribution, soil type)
- Determination of sediment contamination level

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- Determination of binders for stabilisation process
- Development of binder recipe:
- Selection of binder components and their amount;
- Investigation of compression strength development for stabilised sediments
- Determination of sediment leachage properties and toxicity (single stage batch test and Daphnia magna water flea test)
- Turbidity monitoring

Quality control for dredging

The main goal of this stage is to control the effects of dredging on the surface waters and sediments. The working programme includes:

1. Choosing of dredging equipment: (example: backhoe dredger equipped with environmental grab)
2. Sampling and analysis of the water content and contaminants of the dredged material
3. Quality control of dredged sediments:
- Measurements of the water content, density and Ca-content
- Measurements of binder content on the basis of Ca-content of stabilised mixtures
- Testing of the strength development of the stabilised mixtures
- Permeability and leaching tests
4. Reporting of the results

Quality control for stabilisation process

1. Preparatory studies (sediment sampling activities)
2. QC during stabilisation works (sediment sampling, water sampling from the stabilisation basin, analysis of contamination, control of the visibility depth of the water in the stabilisation basin, analysis of the binder content, determination of the strength of the stabilised mass)
3. QC after stabilisation works
4. Reporting of the results

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Geotechnical follow-up tests

- Drilling tests (core samples from the stabilised structure for lab analysis)
- Determination of strength development, water permeability, leaching of contaminants
- Ground water level monitoring (if needed)

Example: QA/QC programme for the field test in Port of Gävle

Sampling, tests and analysis of sediments to be dredged and binder components to be used

The sediments in the fairway and port in the Port of Gävle were sampled 2006, 2008, and 2009 and characterised. Sample spots are given in Figure 1. In 2009, sediments samples were taken in four spots, called “Tunna 1-4”, of which two sample spots, Sediment 2 and Sediment 3, were decided as representative.

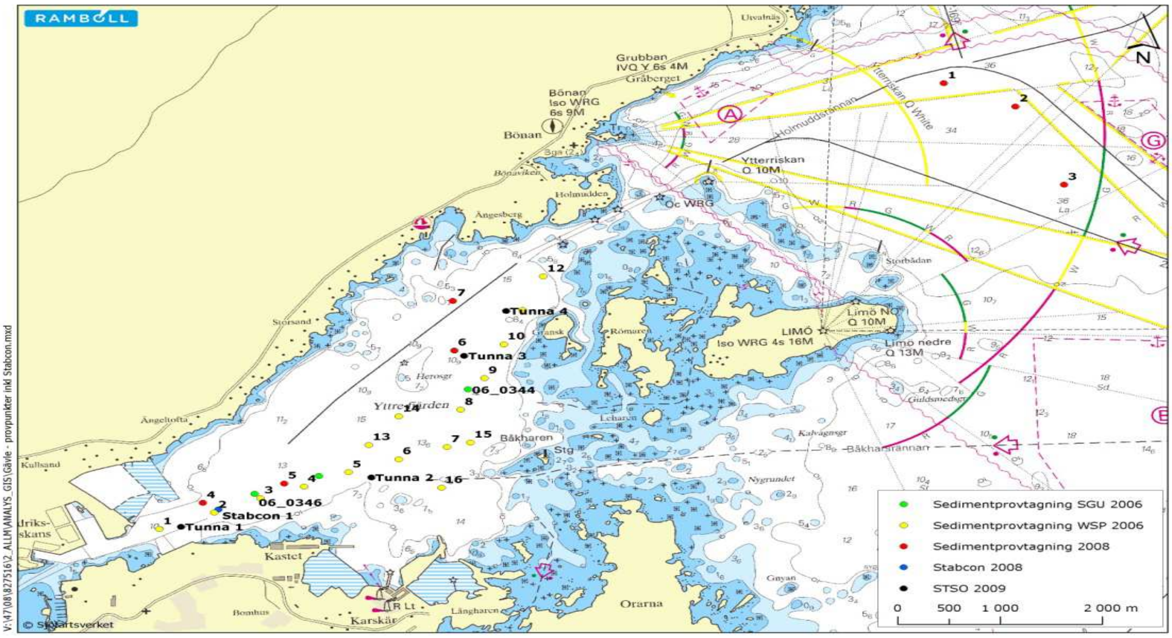

Figure 1. Sample spots in the inner and outer parts of Port of Gävle.

The specific factors that were included in the characterisation are given in Table 1, as well as methods used. The leachates were taken from the one step (L/S 10) batch leaching test.

Analysis of metals, TOC, PAH, PCB and TBT were performed by ALS Scandinavia AB.

The fly-ash (bio fly-ash) was environmentally characterised according to Table 2. The other two binder components to be used were Cement and Merit 5000 (GGBS)

Table 1. Methods and standards for characterisation of sediment from Port of Gävle.

Characteristic	*Investigation*	*Standard method*
Water content	*-*	*SIS-CEN ISO 17892-1*
Particle size distribution	*Water sieve/sedimentation*	*SS EN 933-1, SS 027124*
pH	*-*	*SS-ISO 10390:2007*
Electric conductivity	*-*	*SS-ISO 11265*
Total organic carbon	*Leco analysis*	*CSN ISO 10964 och CSN EN 13137*
Batch leaching test	*L/S=10*	*SS EN 12457-2*
Metals	*Total content*	**1*
Metals	*Leachate*	**2*
PAH	*Total content*	**3*
PAH	*Leachate*	*CSN EN ISO 11396*
PCB	*Total content*	*EN DIN ISO10382*
PCB	*Leachate*	*DIN EN 26468, US EPA 8080A och 8081*
TBT	*Total content*	*DIN ISO 23161 DAR*

**1- Sample preparation for analysis of As, Cd, Cu, Co, Hg, Ni, Pb, B, Sb, S, Se, Zn: Sample dried at 50°C and obtained concentrations were corrected against dry weight at 105°C. Dissolution performed in micro wave oven in sealed Teflon containers with nitric acid/water 1:1. Analysis of Sn done after dissolution with inverse Aqua Regia. For the other basic substances: 0.125 g dried sampled was melted together with 0.375 g LiBO2 and dissolved in HNO3. Analysis was done according to the EPA –methods (modified) 200.7 (ICP-AES) and 200.8 (ICP-MS).*
**2- Analysis of water samples without pre-dissolvment. Sample was made acidic by 1 ml nitric acid (suprapure) per 100 ml, except sample which was made acidic before arrival at the laboratory. Sample not made acidic before analysis of W. Before analysis of Se, sample was dissolved by HCl in autoclave (120°C) during 30 minutes. Before analysis of Ag, the sample was preserved by HCl. Analysis was done according to EPA-methods (modified) 200.7 (ICP-AES) and200.8 (ICP-SFMS). Analysis of Hg was done using AFS according to SS-EN ISO 17852:2008.*
**3- Pre-treatment of samples for analysis of 16 EPA Poly Aromatic Hydrocabons: Samples extracted using Proven acetone/hexane/cyclohexane (1:2:2). Analysis using GC-MS. PAH cancerogenic comprises: Benso(a)anthracene, Chrysene, Benso(b)fluoranthene, Benso(k)fluoranthene, Benso(a)pyrene, Dibenso(ah)anthracene and Indeno(123cd)pyrene.*

Table 2 Used methods and standards for environmental characterisation of fly-ash.

Characteristic	*Investigation*	*Standard method*
Routine	*Water content*	*SIS-CEN ISO 17892-1*
Particle size distribution	*Sedimentation*	*SS 027124*
pH	*-*	*SS-ISO 10390:2007*
Electric conductivity	*-*	*SS-ISO 11265*
Metals	*Total concentrations*	**4*
Organic content	*TOC*	*ISO 13137*
Percentage active CaO	*CaO analysis*	*Nordkalk*

**4- Sample preparation for analysis of As, Cd, Cu, Co, Hg, Ni, Pb, Sb, S, Se, Sn, Zn: Sample was dried at 50°C and analysed concentrations were corrected against dry weight at 105°C. Dissolution was performed according to ASTM D3683 (modified). The rest of analysed elements, dissolution was done according to ASTM D3682 (LiBO2 – smelt). Analysis was done according to EPA methods (modified) 200.7 (ICP-AES) and 200.8 (ICP-SFMS).*

Properties of stabilised sediments

The properties of the stabilised/solidified sediments were determined with respect to both geotechnical and environmental issues.

The geotechnical properties determined were

- Strength by unconfined compression test of samples taken by piston sampling and by CPT (Cone Penetration Testing) at 28, 91 and 365 days after treatment.

- Permeability of samples taken by piston sampling at 28, 91 and 365 days after treatment
- Compression properties by CRS tests (Constant Rate of Strain) on samples taken by piston sampling

The environmental properties determined were by
- Leaching test of samples taken by piston sampling, see Table 1 for methods used
- Analysis of contaminants in water samples taken in environmental tubes installed in the stabilised sediments at 91 and 365 days after treatment.
- Analysis of contaminants in water samples taken in pore pressure equipments installed at different depths in the stabilised sediments at 28, 91 and 365 days after treatment.

Influence on the surroundings

The control of the influence on the surroundings was according to the Figure 2.

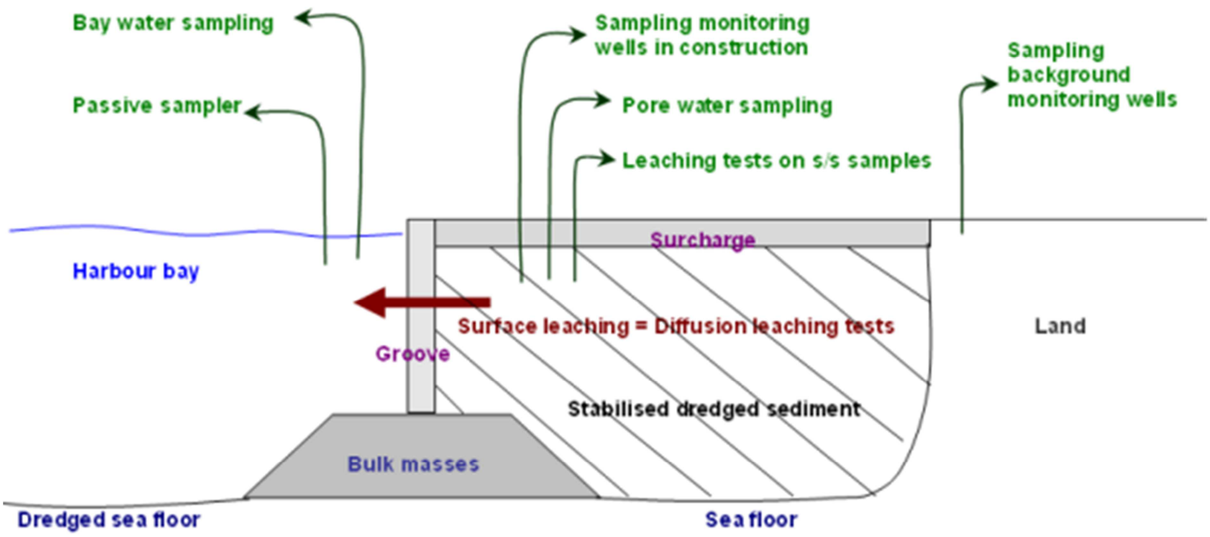

Figure 2. Outline of different environmental sub tasks in the field test in Port of Gävle

Behaviour of structure

The geotechnical performance of the structure versus time after treatment was monitored by
- measurement of horizontal displacement of top of sheet pile wall
- measurement of horizontal displacement of sheet pile wall versus depth by inclinometer on the sheet pile wall
- measurement of vertical displacement by settlement markers on the s/s- treated material
- measurement of vertical displacement by four settlement markers on the top of the fill
- pore pressure in the stabilised sediments

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