MASS STABILIZATION IN INFRASTRUCTURE AND ENVIRONMENTAL CONSTRUCTION

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MASS STABILISATION IN INFRASTRUCTURE AND ENVIRONMENTAL CONSTRUCTION

1. GEOTECHNICAL AND ENVIRONMENTAL APPLICATIONS
2. ROADS, PROJECT DEMONSTRATION
3. MUNICIPAL ENGINEERING APPLICATIONS
4. RAILWAYS
5. LESSONS LEARNED
MASS STABILISATION IN INFRASTRUCTURE CONSTRUCTION

- Roads
- Streets and municipal engineering
- Railroads
- New or existing railroad
- Existing railroad
MASS STABILISATION IN INFRASTRUCTURE CONSTRUCTION

Harbours

Sea routes (Fairways)

Outdoor activity centres

Green areas and landscaping
MASS STABILISATION IN ENVIRONMENTAL CONSTRUCTION

Noise barriers

Flood protection dams and embankments

Vibration reducing (beside or under railroad)
MASS STABILISATION IN ENVIRONMENTAL CONSTRUCTION

Reactive walls

Sealing layer of landfill structure

Solifidication of contaminated sediment or soil masses in harbour or in noise barriers (etc.)
ROADS

The function of mass stabilization:
- reduce settlement
- improve the total stability
- increase the load-bearing capacity of the subgrade
- improve the properties of low-quality soils and to utilize them in embankment filling
- prevent forming of poor quality surplus soils (stabilization prior to excavation)
MASS STABILIZATION PROJECT, ROAD (FUEL STATION), HAMINA, FINLAND

Project demonstration (design and quality control):
1. geology
2. stabilisation tests
3. cost estimations
4. dimensioning
5. technical drawings, work specifications, quality assurance plan
6. quality control
1. Geology:
- clay and mud layer 0...7 meters
- sand, glacial till and bed rock under clay layer
- shear strength 4...6 kN/m² (vane, unreduced)
- water content 100...400 %
- ground water level ≈ ground surface level
2. Stabilization tests in laboratory:
- 2 sampling depths
- 2 binders
- 2...4 binder amounts (kg/m³)
- 28 days hardening time
- 1-axial compression tests
- good hardening with binder Nordkalk GTC 75 kg/m³

=> shear strength 60...90 kPa is easy to achieve ($\tau = \frac{\sigma}{2}$)

GTC = Nordkalk GTC (gypsum + lime + cement)
KC 3:7 = lime 30 % and cement 70 %
3. Cost estimation:
Comparison to other potential foundation engineering methods:
- Pile foundation => expensive
- Mass replacement => “brutal” method to near by structures, high price of the surplus soft soil
- Light weight fill => too big settlements, stability?, high price
- Column stabilisation with overlapping columns => ok!
- Mass stabilisation => ok! (more suitable in this case)
4. Dimensioning: Stability calculations

- stability calculations without foundation structures (1) and with deep stabilisation (2)

- 1) safety factor against failure \( F = 0.62 \ll 1.8 \)

- 2) \( F = 1.803 > 1.8 \), when shear strength of mass stabilised soil is 40 kPa

- NOTE! weaker layer in the bottom of mass stabilization over hard glacial till layer

Settlement calculations:

- 1) \( >700 \text{ mm (theoretical because } F \ll 1.0 \)

- 2) \( \approx 60 \text{ mm (after hardening of mass stabilization)} \)
## SOME TYPICAL PARAMETERS OF MASS STABILIZED SOIL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal value</th>
<th>Test method</th>
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| Shear Strength \( \tau, \tau = c + \sigma \tan \phi \) | 50...200 kPa  | 1-axial compression test  
(3-axial in special cases => \( c + \phi \)) |
| Modulus, \( E_{50} \) during hardening | 0,1...0,3 MPa \((S_{\text{initial}})\) | curing time settlement of test specimen                                      |
| Modulus, \( E_{50} \) after hardening    | 10...80 MPa \((S_{\text{final}})\) | 1-axial compression test  
in practise \( E_{50} = 350...450 \times \tau_{\text{stabilized}} \) |
| Water Permeability, \( k \)     | \( 1 \times 10^{-8}...10^{-10} \) m/s | CRS-test, flexible wall permeameter                                           |
MASS STABILIZATION PROJECT, ROAD, HAMINA

5. Technical drawings, work specifications, quality assurance plan, etc.

Target shear strength 40 kPa
Binder GTC 75 kg/m³

Mass stabilization
area border

designed embankment
mud...clay
clay
sand
MASS STABILIZATION PROJECT, ROAD, HAMINA

6. Quality control
   - after hardening time
   - with column penetrometer (normally)

Mass stabilization work and construction of compaction embankment

shear strength in situ > target shear strength => ok!

=> Construction of the final embankment
MUNICIPAL ENGINEERING APPLICATIONS

The function of mass stabilization:
- to reduce settlement of the subgrade
- to improve stability of the pipe trenches
- hardening soft excavated soils to enable re-use in backfilling works in pipeline trenches or elsewhere

The requirements for the pipe settlement are generally more tight than in the case of a street structure alone.
The effect of weak zones depends on the purpose of the stabilization and the scale of the sliding surface.

Large sliding surface under an embankment => small local weak zone is not “dangerous”

Short sliding surface in the slope of excavation => weak zone is “dangerous” (and sheet pile support or support with bracing elements may be needed)
RAILROADS

The function of mass stabilization:

• ground improvement of a new embankment or existing railroad embankment requiring repair under the embankment

• strengthening the ground adjacent to an old railroad embankment built on a soft soil

Stability of an existing railway embankment was improved by a counter-weight embankment built in the soft soil area treated with mass stabilization
RAILROADS

CASE KOTOLAHTI, KOTKA, FINLAND

Mass stabilization, $z_{\text{subsoil}} < 5$ m
Column stabilization $z_{\text{subsoil}} > 5$ m
Water content 50...160 %
Shear strength 7...11 kN/m$^2$

Railway yard
1 old track and 11 new tracks
5. LESSONS LEARNED

Mass stabilization is a versatile method to improve soft soils and the variation of applications is huge.

Almost every type of soft soils have been mass stabilized (clay, silt, gyttja, peat, dredged soft sediments, contaminated soils, etc.) during two decades of mass stabilization.

The dimensioning and design of mass stabilized applications are basically quite simple, but there are many issues which needs a lot of experience and understanding of the stabilized material and stabilization method.

Mass stabilization method is quite new method and it is continuously developing (machinery, binders, dimensioning, quality controlling methods, ...)

RAMBØLL
Thank You