MASS STABILIZATION IN INFRASTRUCTURE AND ENVIRONMENTAL CONSTRUCTION

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Ramboll Finland Oy

MASS STABILISATION CONFERENCE 2015

22.-24.4.2015
SIBELIUS HALL, LAHTI, FINLAND

MASS STABILISATION IN INFRASTRUCTURE AND ENVIRONMENTAL CONSTRUCTION

1. GEOTECHNICAL AND ENVIRONMENTAL APPLICATIONS

2. ROADS, PROJECT DEMONSTRATION

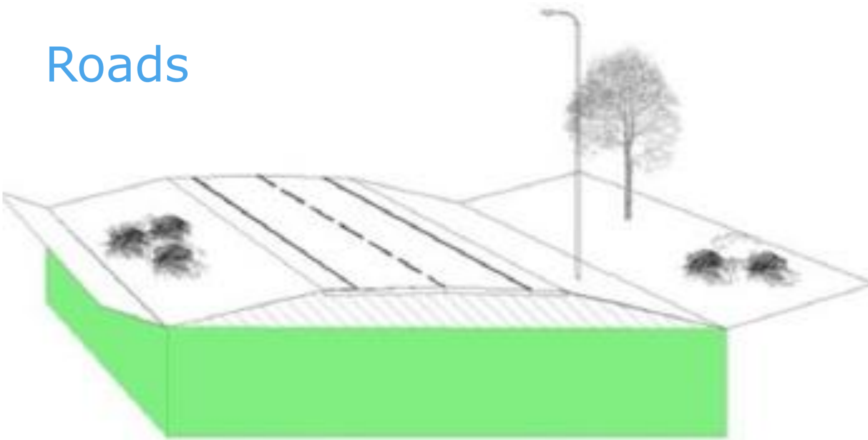
3. MUNICIPAL ENGINEERING APPLICATIONS

4. RAILWAYS

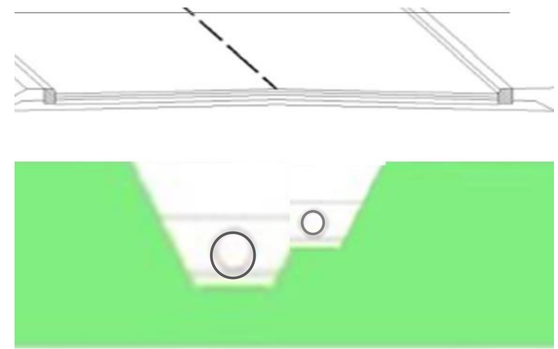
5. LESSONS LEARNED

MASS STABILISATION IN INFRASTRUCTURE CONSTRUCTION

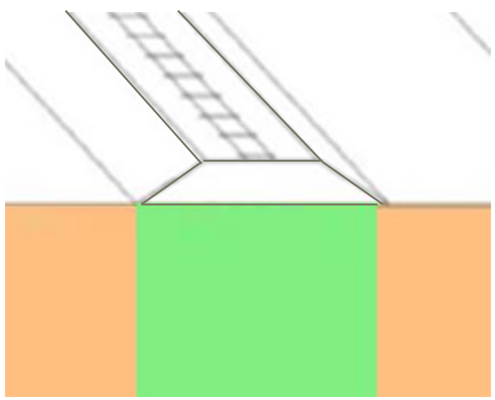
Roads



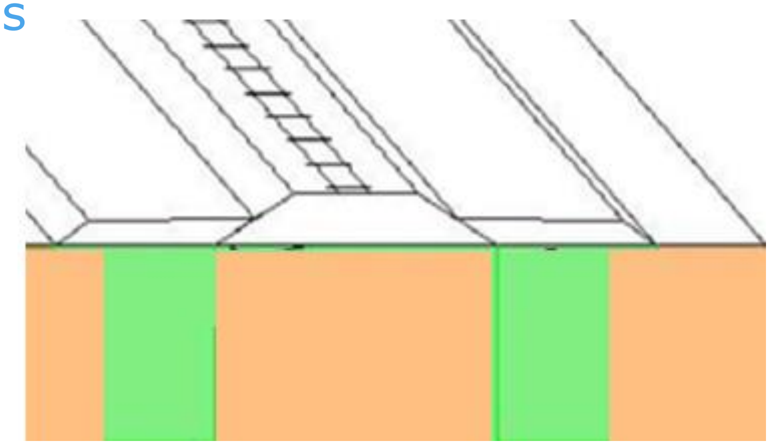
Streets and municipal engineering



Railroads



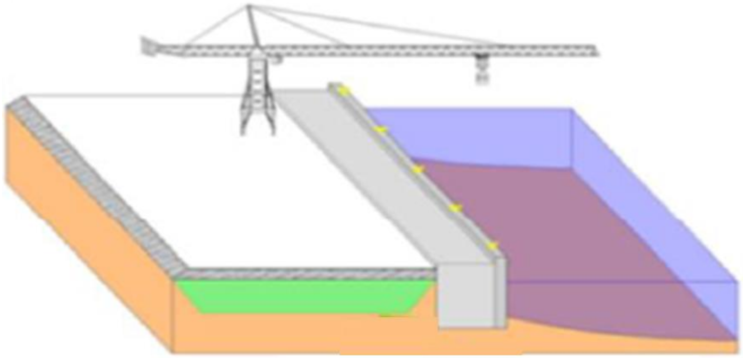
New or existing railroad



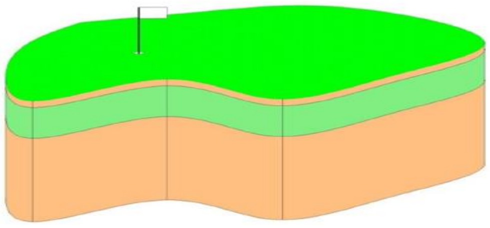
Existing railroad

MASS STABILISATION IN INFRASTRUCTURE CONSTRUCTION

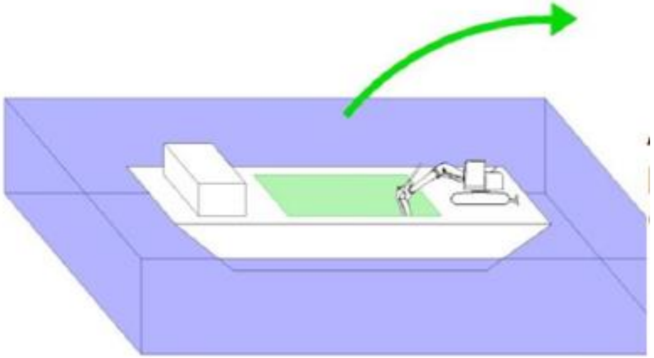
Harbours



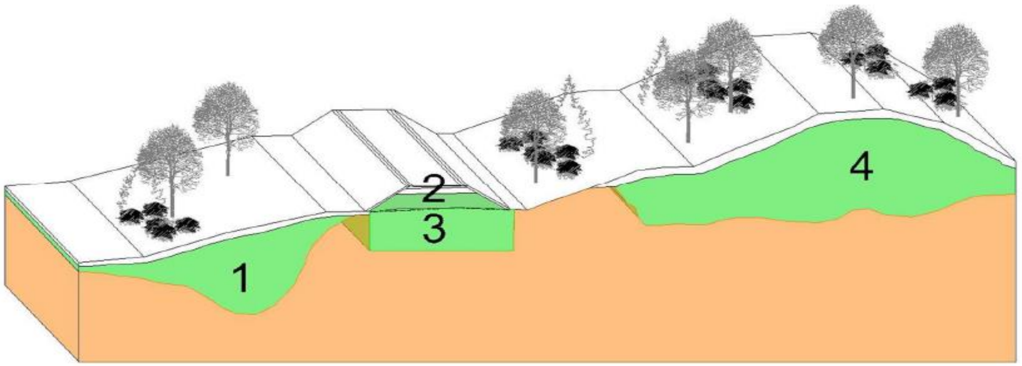
Outdoor activity centres



Sea routes (Fairways)

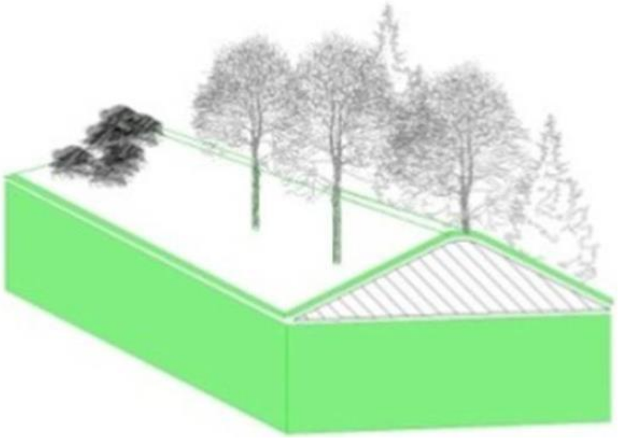


Green areas and landscaping

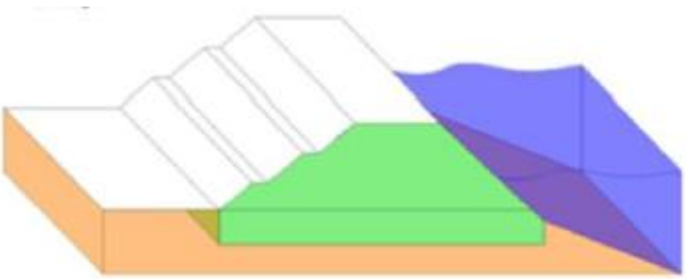


MASS STABILISATION IN ENVIRONMENTAL CONSTRUCTION

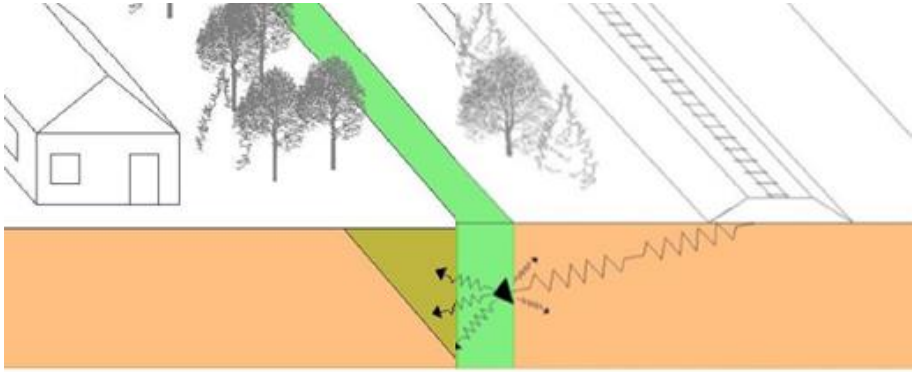
Noice barriers

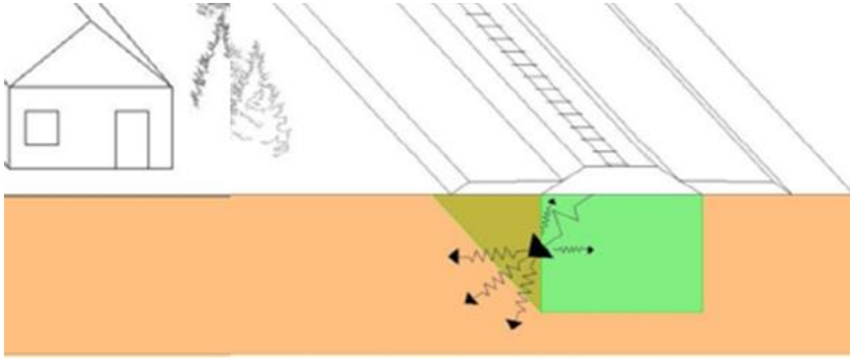


Flood protection dams
and embankments



Vibration reducing (beside or under railroad)

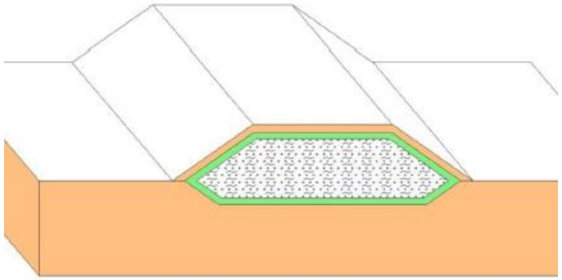




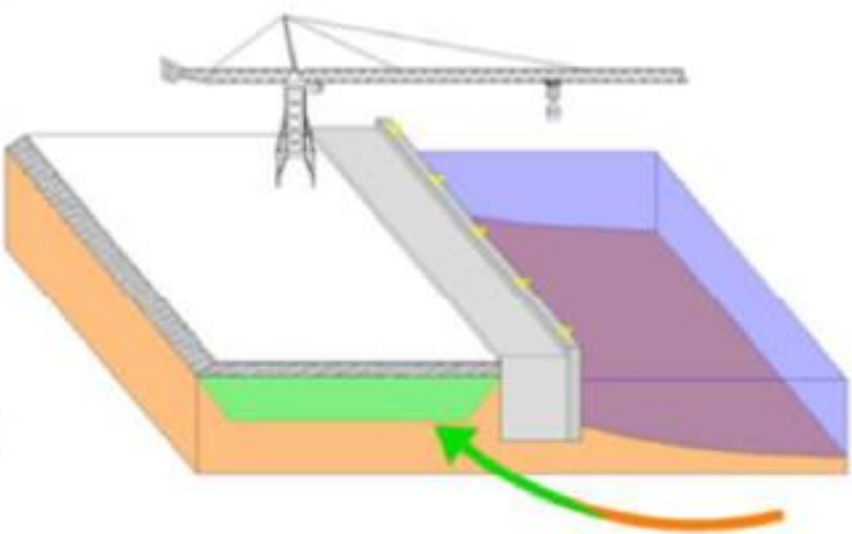
MASS STABILISATION IN ENVIRONMENTAL CONSTRUCTION

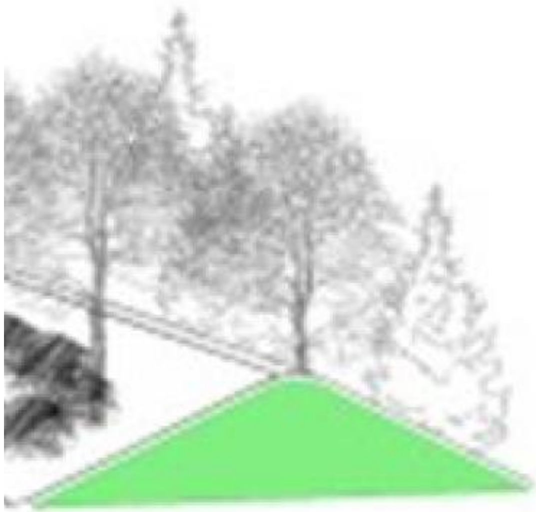
Reactive walls

Sealing layer of landfill structure



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

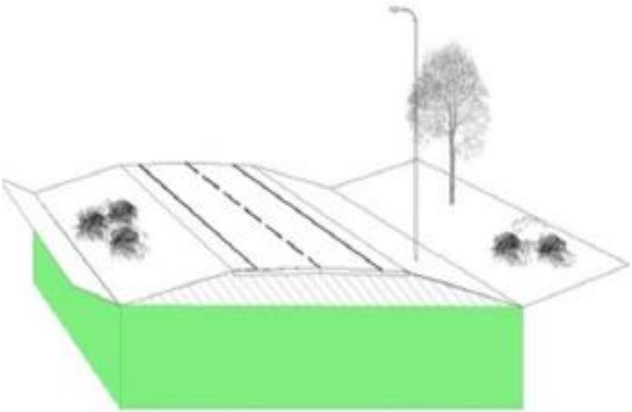


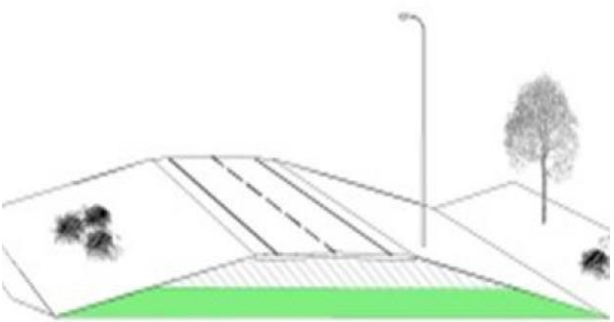


ROADS

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)





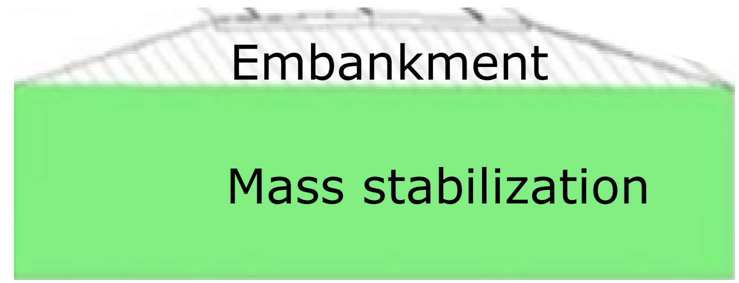
Before After

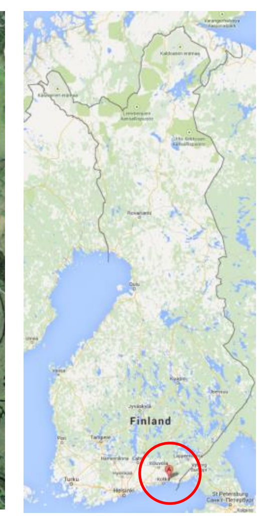
RAMBOLL

MASS STABILIZATION PROJECT, ROAD (FUEL STATION), HAMINA, FINLAND

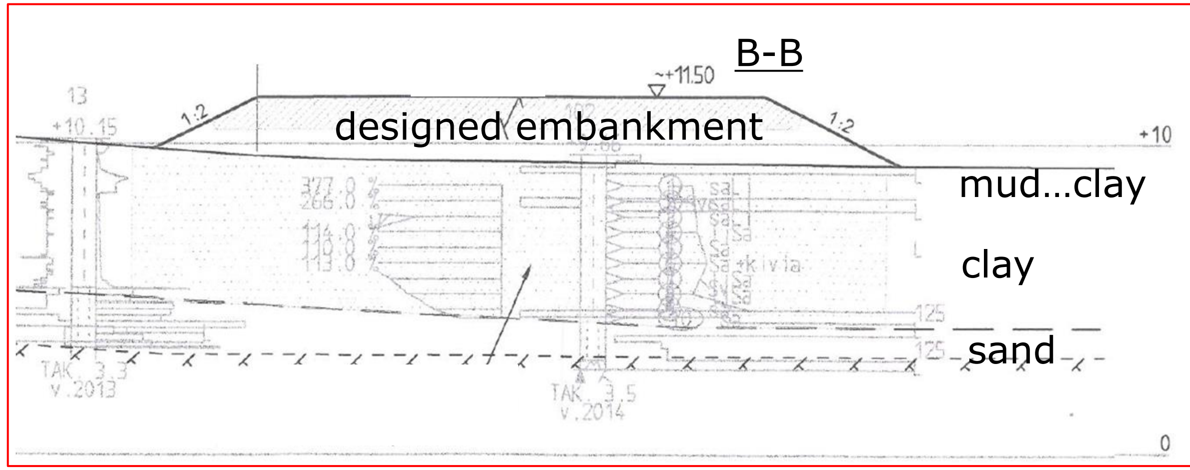
Project demonstration
(design and quality control):

1. geology
2. stabilisation tests
3. cost estimations
4. dimensioning
5. technical drawings, work specifications, quality assurance plan
6. quality control



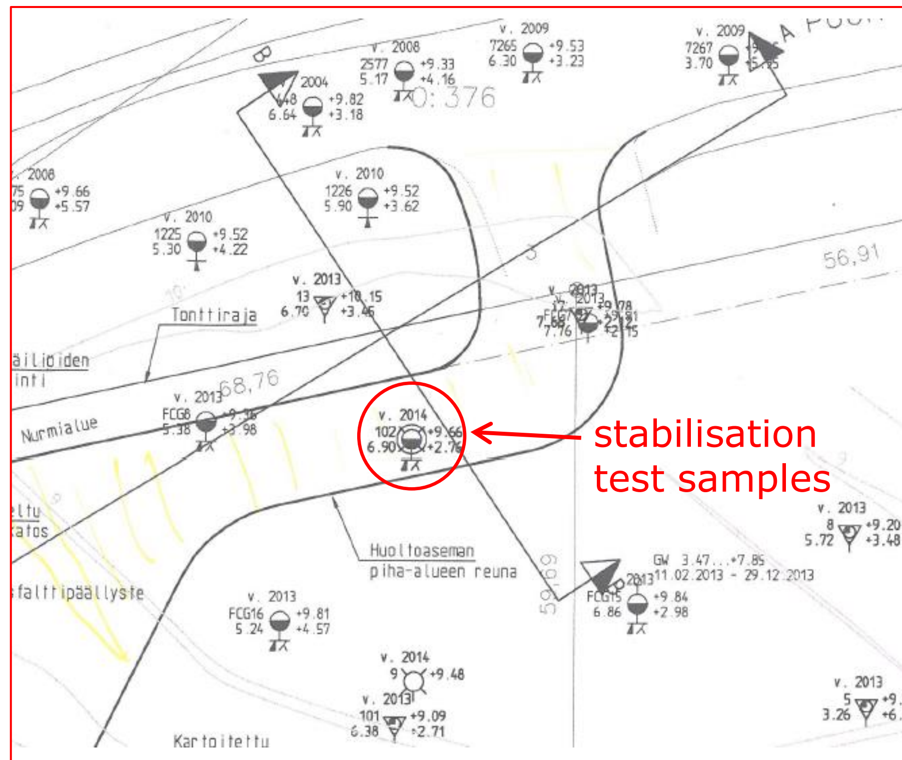


MASS STABILIZATION PROJECT, ROAD, HAMINA



1. Geology:

- clay and mud layer 0…7 meters
- sand, glaciall till and bed rock under clay layer
- shear strength 4…6 kN/m^2 (vane, unreduced)
- water content 100…400 %
- ground water level ≈ groung surface level



MASS STABILIZATION PROJECT, ROAD, HAMINA

2. Stabilization tests in laboratory:

- 2 sampling depths
- 2 binders
- 2…4 binder amounts (kg/m^3)
- 28 days hardening time
- 1-axial compression tests
- good hardening with binder Nordkalk GTC 75 kg/m^3

=> shear strength 60…90 kPa is easy to achieve ($\tau = \sigma / 2$)

Toimitettujen näytteiden luokitteluomina

Piste	syvyys	w [%]	ρ_m [kg/m^3]	LOI [%]	maalaji 1)
	2 m	126	1360	8.2	Clay
	3.5 m	98.2	1440	4.4	

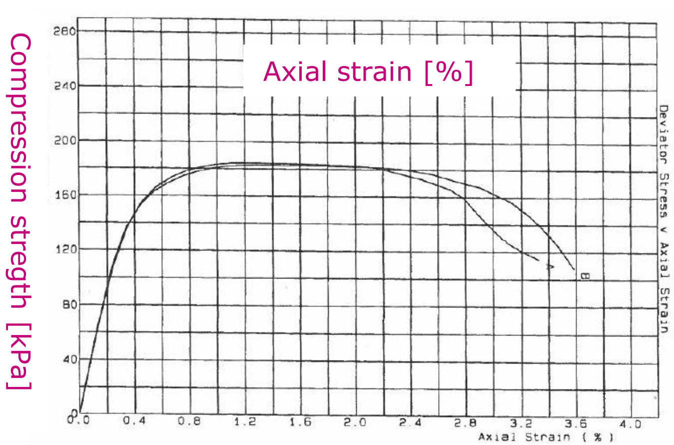
1) Silmämääräinen maalajiarviointi.

Stabiloituvuustutkimukset

Piste	syvyys	Sideaine	määrä [kg/m^3]	Compression strength [kPa] 28 days	Pa] a
	2 m	GTC	75	133	x
			100	135	x
			125	143	x
			150	156	x
		KC 3:7	75		xx
			100	69	x
			125	104	x
			150	154	x
			180		xx
	3.5 m	GTC	50	82	x
			75	184	x
			100		xx

x = koestamatta jäänyt varakappale.

GTC = Nordkalk GTC (gypsum + lime + cement)
KC 3:7 = lime 30 % and cement 70 %



Nordkalk

FINNSEMENTTI

MASS STABILIZATION PROJECT, ROAD, HAMINA

3. Cost estimation:

Comparison to other potential foundation engineering methods:

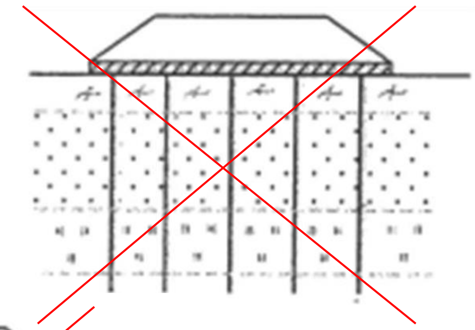
- Pile foundation => expensive
- Mass replacement => “brutal” method to near by structures,

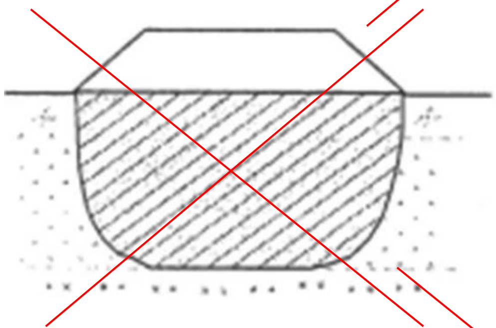
  high price of the surplus soft soil
- Light weight fill => too big settlements, stability?, high price

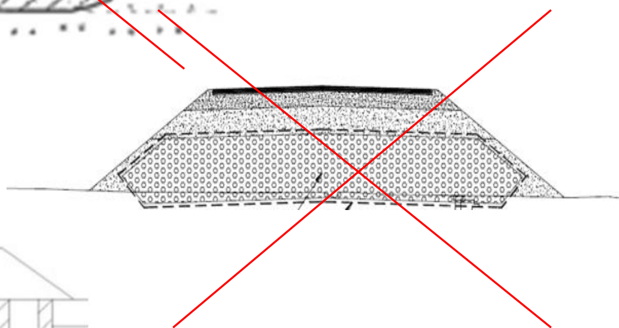
- Column stabilisation with overlapping columns => ok!

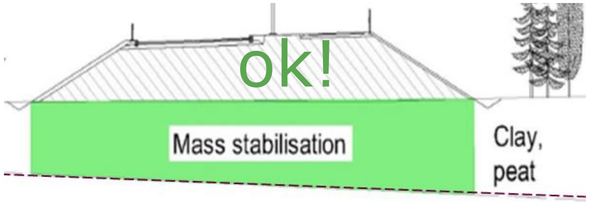
- Mass stabilisation => ok!

  (more suitable in this case)







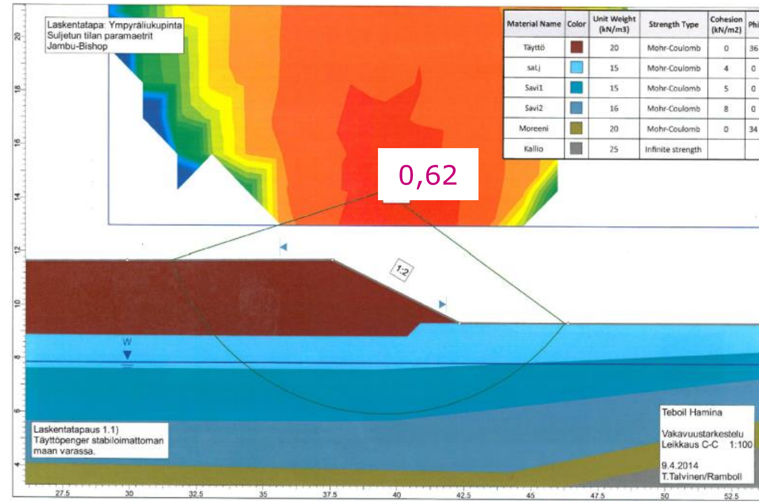


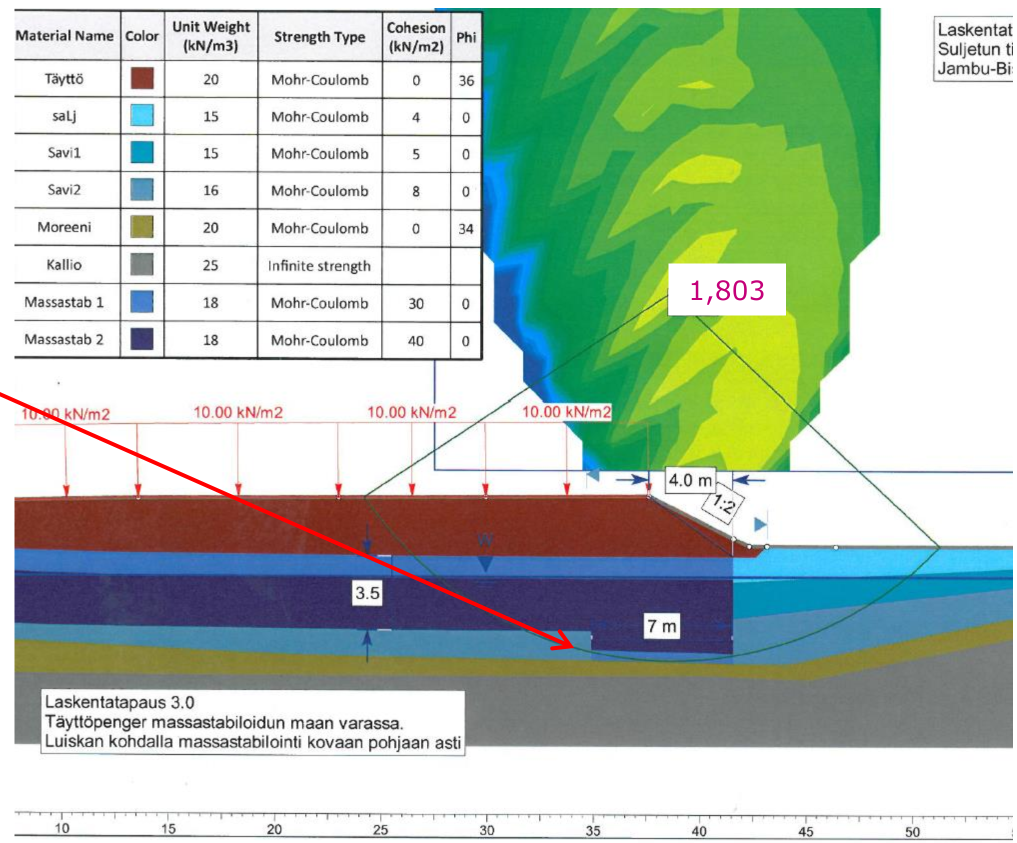
MASS STABILIZATION PROJECT, ROAD, HAMINA

4. Dimensioning:

Stability calculations

- stability calculations without foundation structures (1) and with deep stabilisation (2)
- 1) safety factor against failure F = 0,62 <<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 glaciall till layer



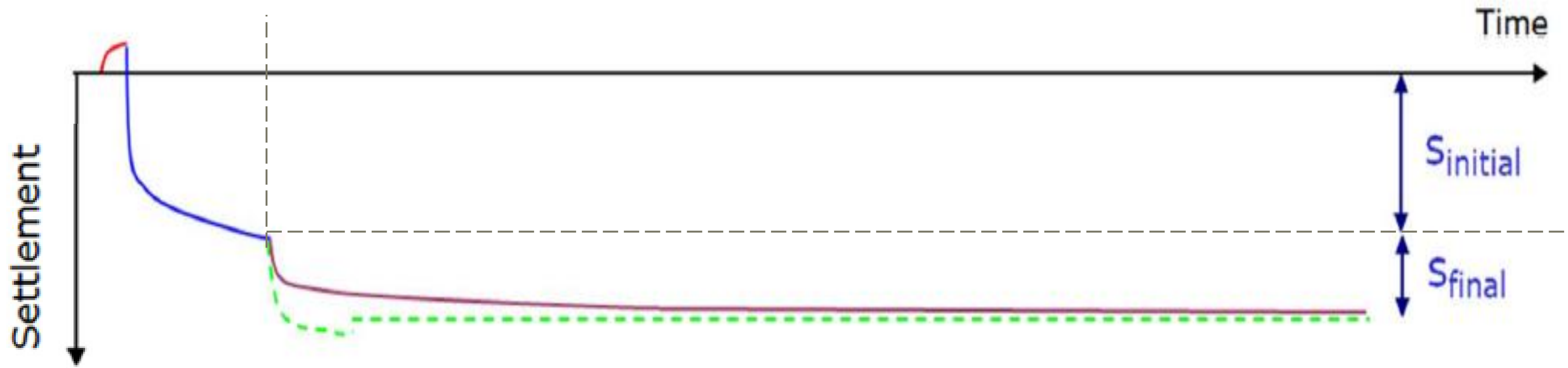


Settlement calculations:

- 1) >700 mm (theoretical because F << 1,0
- 2) ≈60 mm (after hardening of mass stabilization)

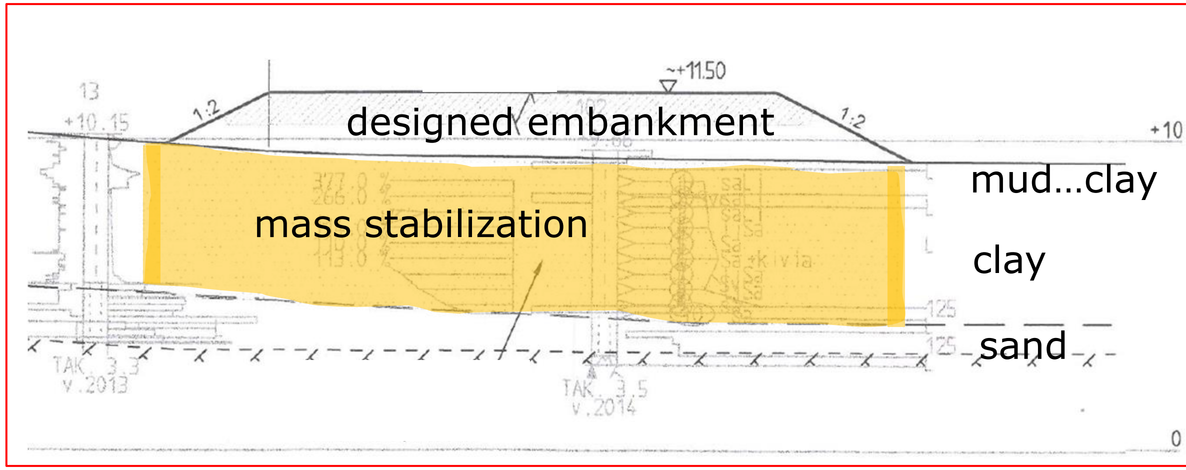
SOME TYPICAL PARAMETERS OF MASS STABILIZED SOIL

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



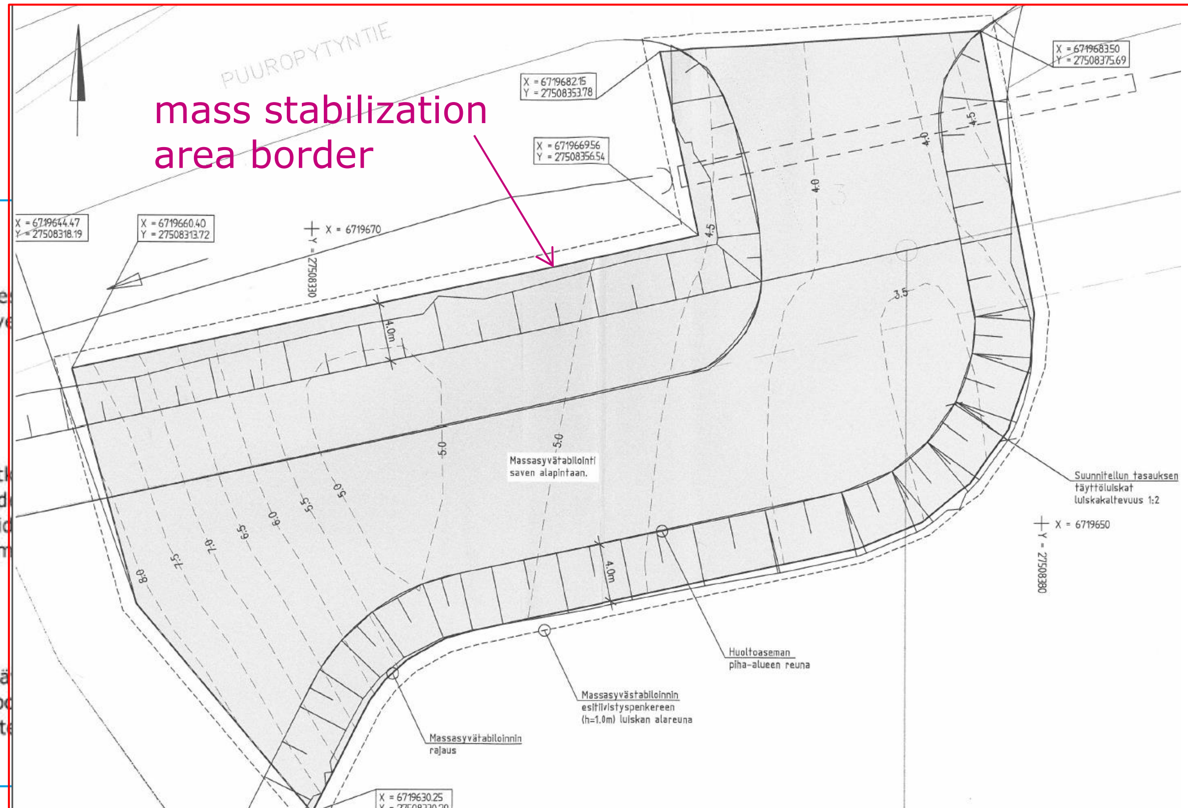
MASS STABILIZATION PROJECT, ROAD, HAMINA

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



Target shear strength 40 kPa

Binder GTC 75 kg/m³



14132.0 Stabiloinnin tavoitetaso ja lujuusvaatimus

Stabiloinnin tavoitetaso:
Massasyvästabiloitavan alueen kulmapisteiden koordinaatit on e
104. Koko stabiloitavalla alueella massastabilointi ulotetaan save
tavoitetaso on esitetty korkeuskäyrinä piirustuksessa 103.

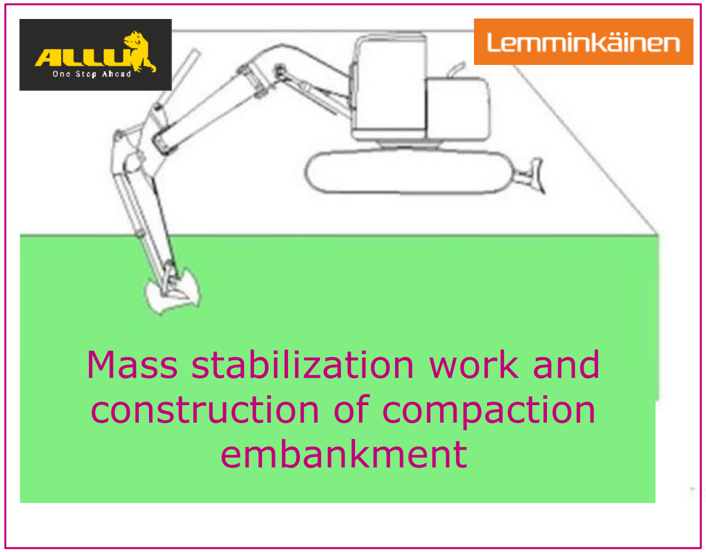
Lujuusvaatimukset:
Massastabiloinnin tavoiteleikkauslujuus on 40 kPa.

Lujuusvaatimus tulee saavuttaa 3 kk ikäisenä. 1 kk ikäisenä tutk
massastabiloinnin lujuuden tulee olla ≥ 80 % 3 kk tavoitelujuud
tutkittuna ≥ 90 % 3 kk tavoitelujuudesta. Mahdollisille muille sid
kertoimet määritetään tarvittaessa erikseen ennen työn aloittam

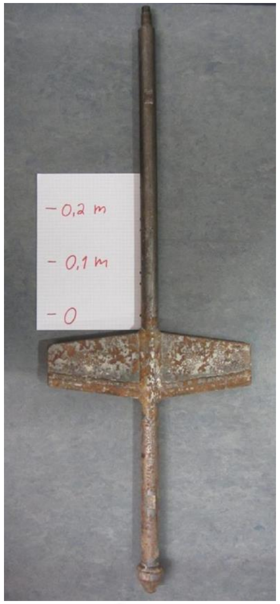
14132.1 Massastabiloinnin materiaalit

Sideaine ja sideainemäärä
Stabiloinnissa käytetään sideaineena GTC:tä 75 kg/m³. Käytettä
perustuu laboratoriossa tehtyihin puristuslujuuskokeisiin (Rambo
Urakoitsija voi esittää muutakin sideainetta laboratoriokoetuloste
aikaisemmin tehtyjen stabilointien kokemusten perusteella.

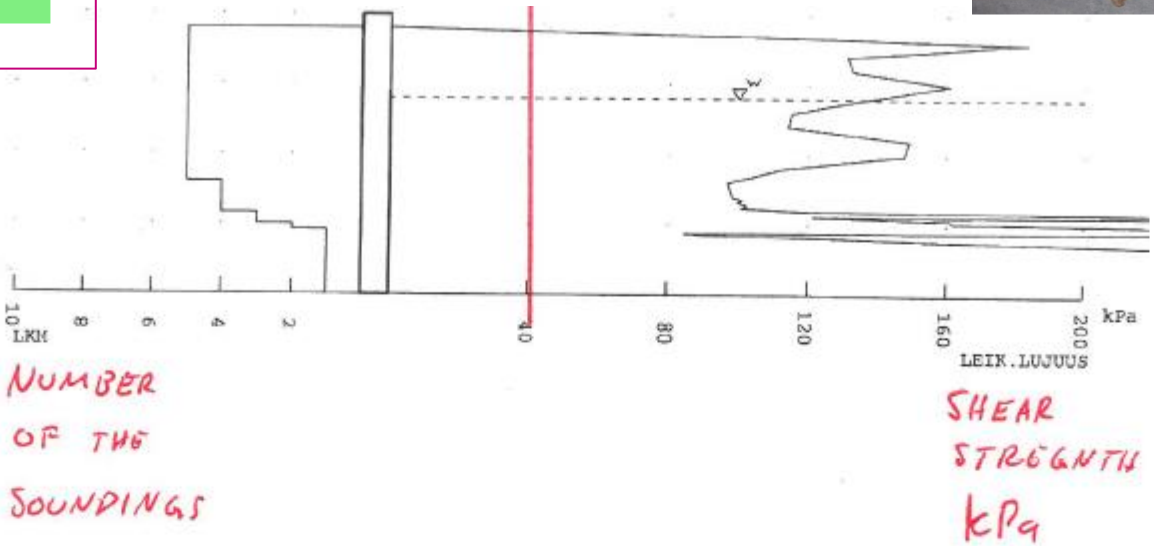
MASS STABILIZATION PROJECT, ROAD, HAMINA



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



Target shear strength 40 kPa



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

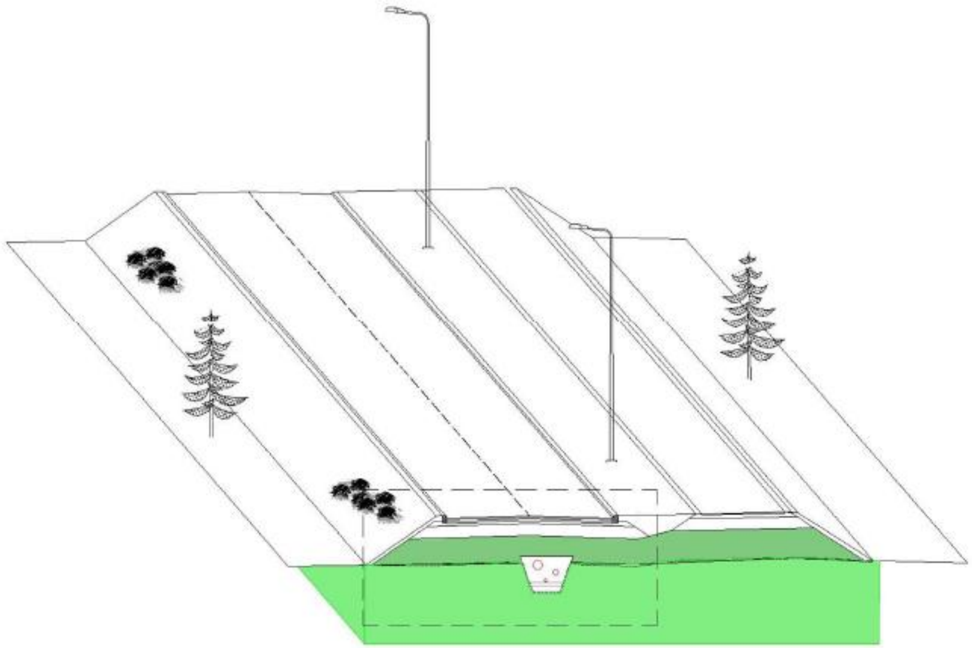
=> Construction of the final embankment

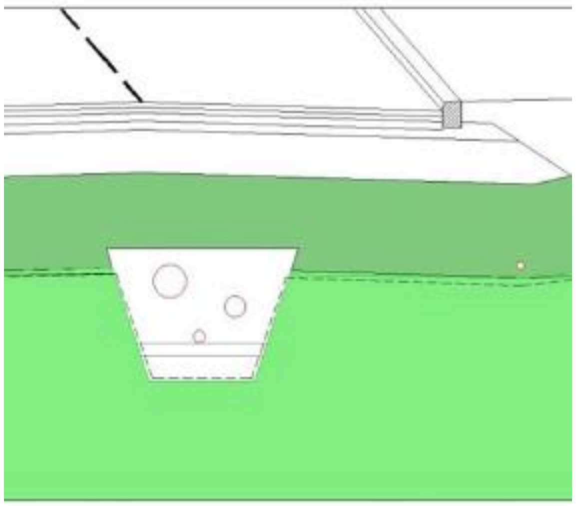
MUNICIPAL ENGINEERING APPLICATIONS

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.

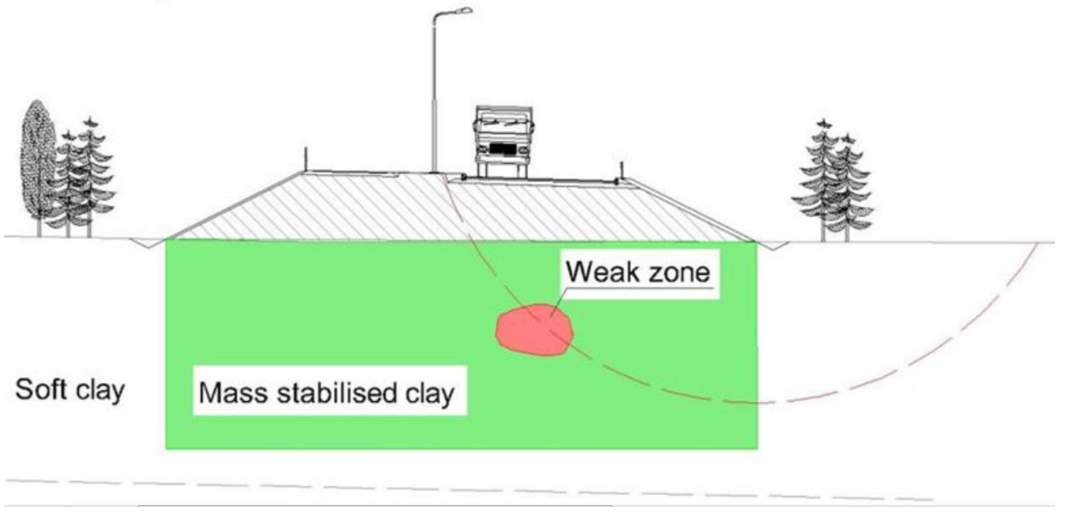




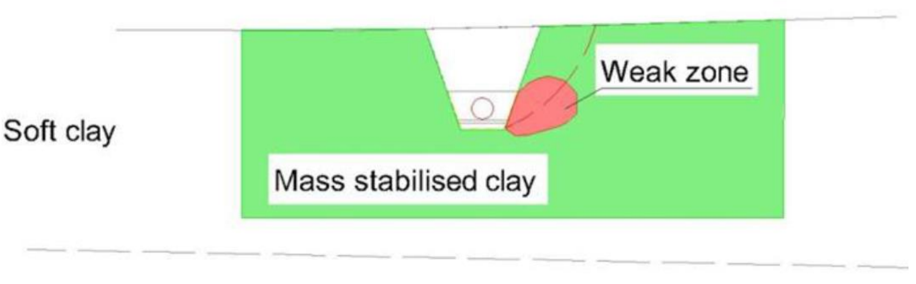
MUNICIPAL ENGINEERING APPLICATIONS

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”



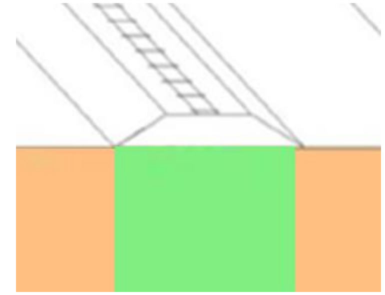
Short sliding surface in the slope of excavation => weak zone is ”dangerous” (and sheet pile support or support with bracing elements may be needed)

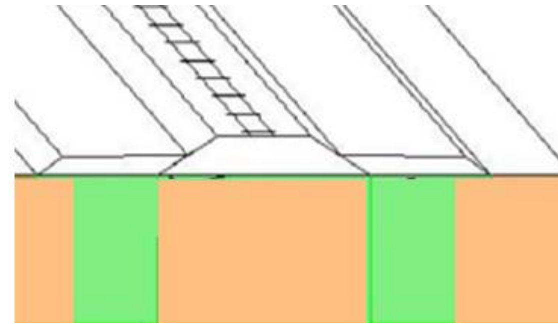


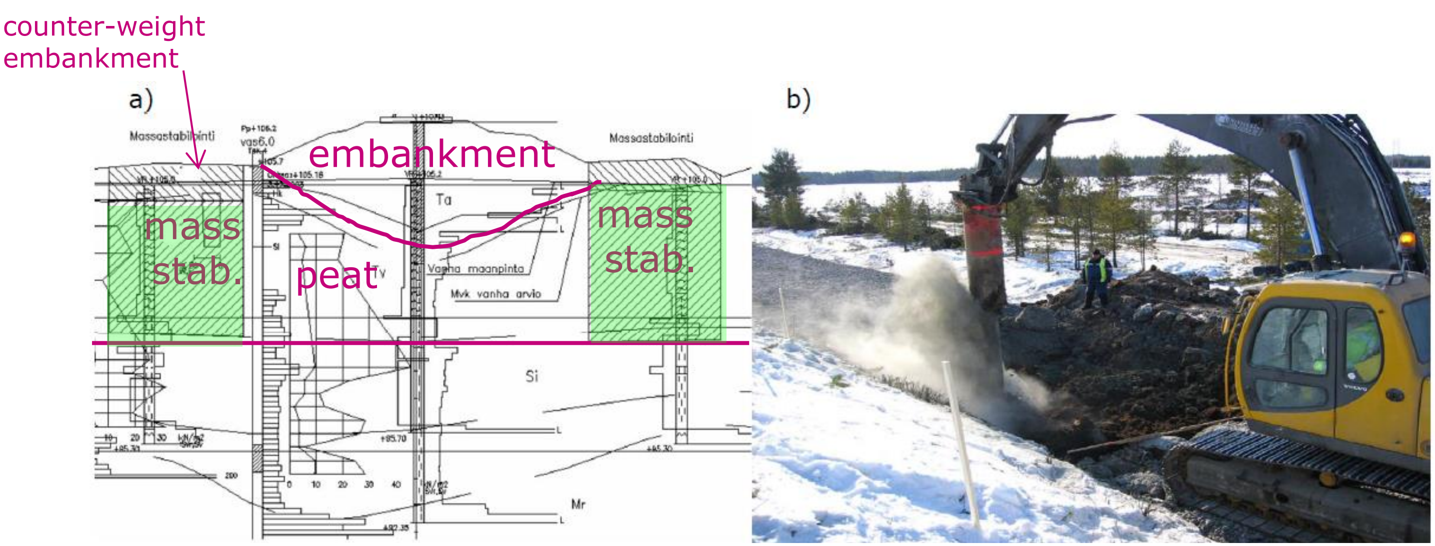
RAILROADS

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

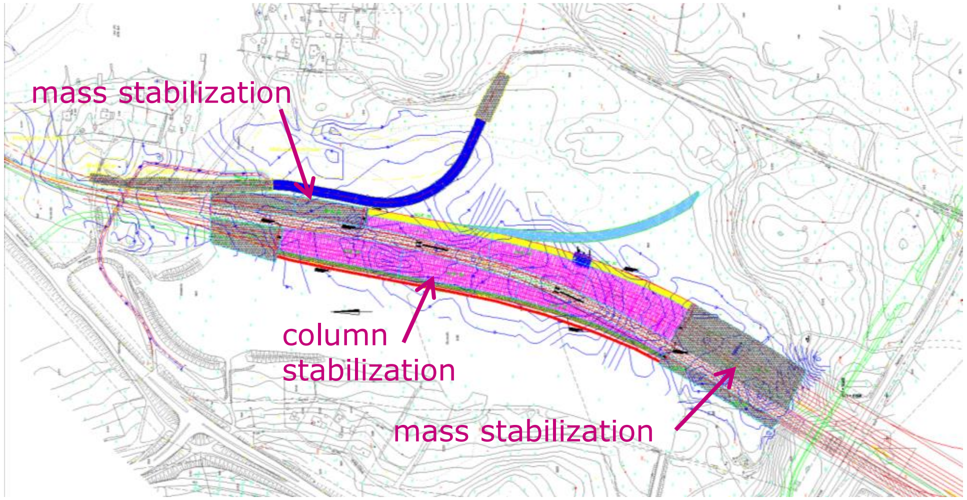
CASE KOTOLAHTI, KOTKA, FINLAND

Mass stabilization, $z_{subsoil} < 5$ m

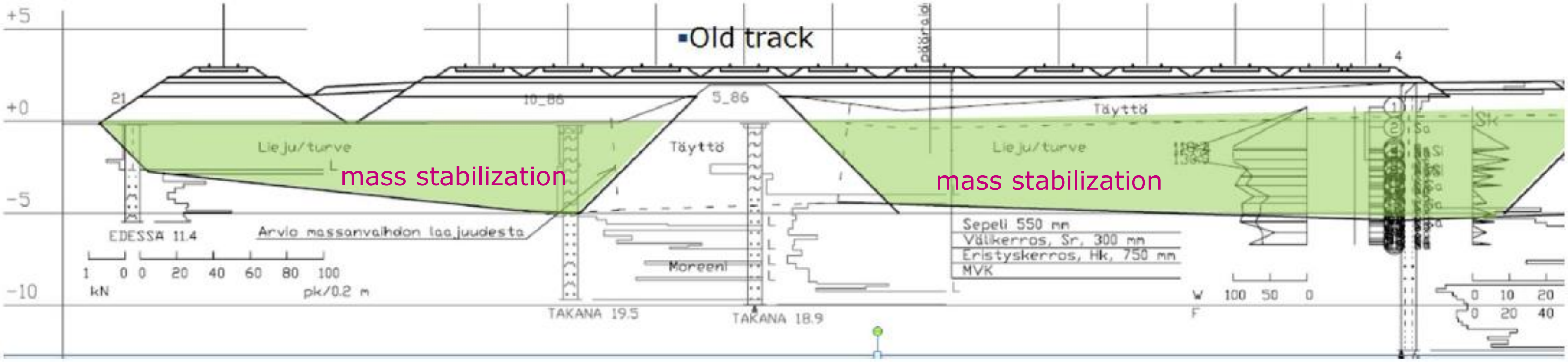
Column stabilization $z_{subsoil} > 5$ m

Water content 50…160 %

Shear strengt 7…11 kN/m²



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 basicly 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, …)

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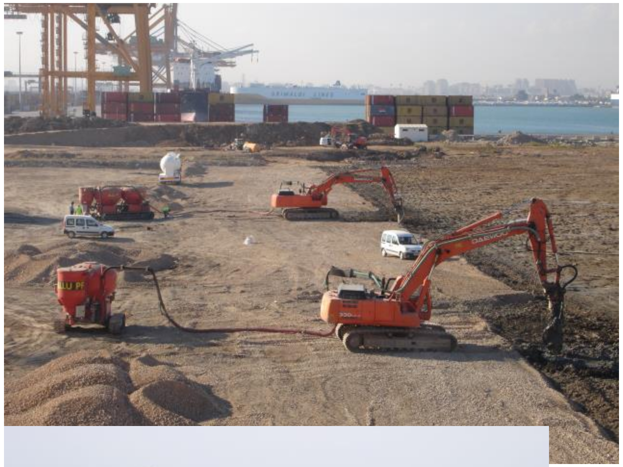
Thank You





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