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“Management of Environmentally Sound Recycling of Oil Shale Ashes into Road Construction Demonstration in Estonia”

OSAMAT Project Manager, Tallinn,Estonia

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OSAMAT Project Goals

- OSA is a valuable construction material
- OSA utilisation is safe for the environment

„Use of oil shale ash in road construction“ - guidlines for European practice

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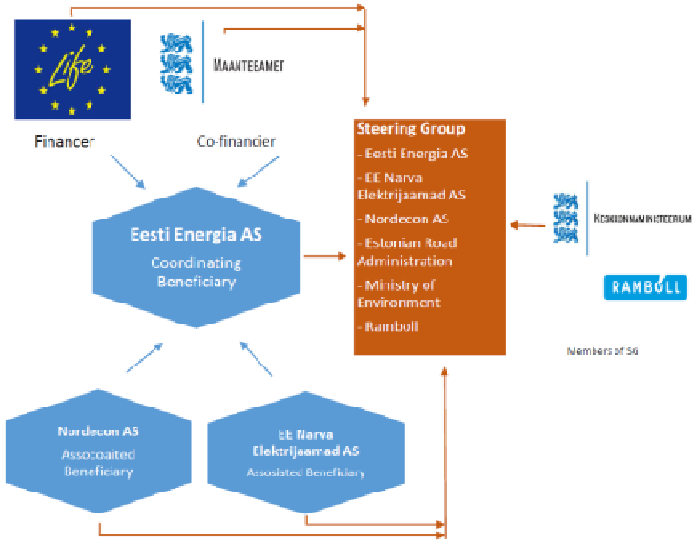
OSAMAT project

Project webpage www.osamat.ee
Project duration 2010-2016



- OSAMAT is financed by EC financial instrument LIFE + program. Estonian Road Administration (ERA) – co-financier of the Project.
- Project budget is 2 379 280 €,
  - 1 142 490 € LIFE program,
  - 700 000 € ERA,
  - 536 790 € Project beneficiaries (EE, EE NEJ, Nordecon).
- Consultancy
  - Ramboll Finland, Skepast&Puhkim AS,
  - Teede Tehnokeskus AS, KBFI (National Institute of Physics and Biophysics)

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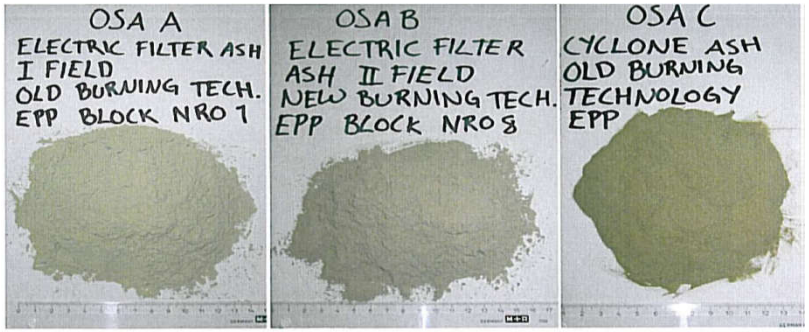
Oil shale ash

- Is a product of combustion of oil shale under t=1400 ° C (pulverized firirng) and t= 900 ° C (circulated fluidized bed combustion)
- Calcareous



Type of OSA	Boiler type, firing temperature	Specific surface, kg/m^2	CaO	CaO free, %	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	K_2O	Na_2O
CYCL PF	Pulverised firing, up to 1400 ^0C	86-150	56	18-24	22,1	11,9	4,9	4,0	1,5	1,5	0,1
BF PF	Pulverised firing, up to 1400 ^0C	280-320	39	6-14	25,7	6,7	3,9	4,7	7,3	3,7	0,1
EF CFB	Circulated fluidised bed combustion, firing temperature up to 900 ^0C	450-800	28	1,6-8	38,6	5,8	5,1	4,5	4,1	4,5	0,2

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OSAMAT Project pilot activities

- Two pilot sections
  - Narva-Mustajõe
  - Simuna-Vaiatu
- Two construction technologies
  - Layer-stabilisation (cold-recycling)
  - Mass-stabilisation
- Three types of OSA
  - Cycl PF, BF PF, EF CFB

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OSAMAT Project implementation

Year	Activities	Outcomes
2010-2011	Preparations: agreements, pilot sites location, recipes development, laboratory testing, compilation of technical design projects	1) project design 2) 3 recipes Narva-Mustajõe, 5 recipes Simuna-Vaiatu
2011-2012	Construction of Narva-Mustajõe pilot site	1) 1, 6 km constructed N-M pilot section 2) construction quality control and start of technical and environmental monitoring at N-M
2013	Mass-stabilisation of peat at Simuna-Vaiatu pilot site	1) 500m (10 000m3) of stabilised peat 2) construction quality control and start of technical and environmental monitoring at S-V
2014	Layer stabilisation onto stabilised peat at S-V pilot site	1) 900 m constructed S-V pilot section 2) Technical and environmental monitoring continued
2015	Technical and environmental monitoring at N-M and S-V pilot sites	1) Technical and environmental monitoring are finished
2016	Project outcomes documentation compilation and the end of the project	August 2016: 1) Guidelines for European practice 2)Verification Report and other reports

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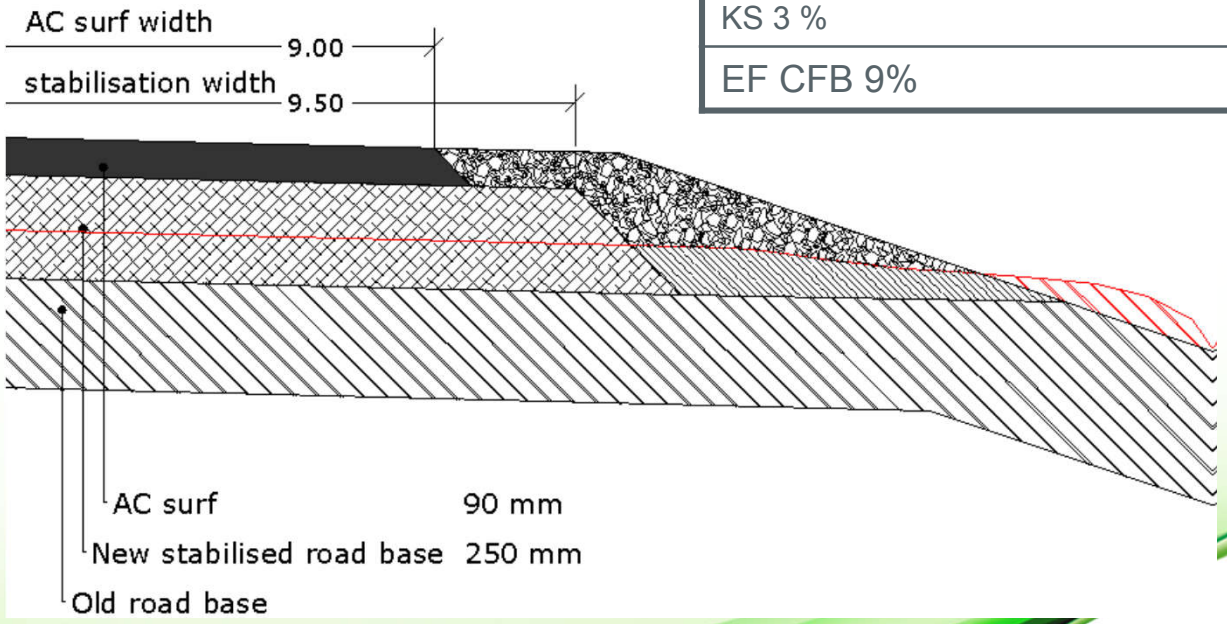
Pilot construction (1)

- Narva-Mustajõe layer stabilisation
  - Pilot section length - 1630 m
  - 3 types of OSA used

OSA type, recipe	Section length, m
Cyclone (Cycl 5% + KS 5%)	780
BF PF (deSOx) (EF PF 6 % + KS 3 %	650
EF CFB 9%	200



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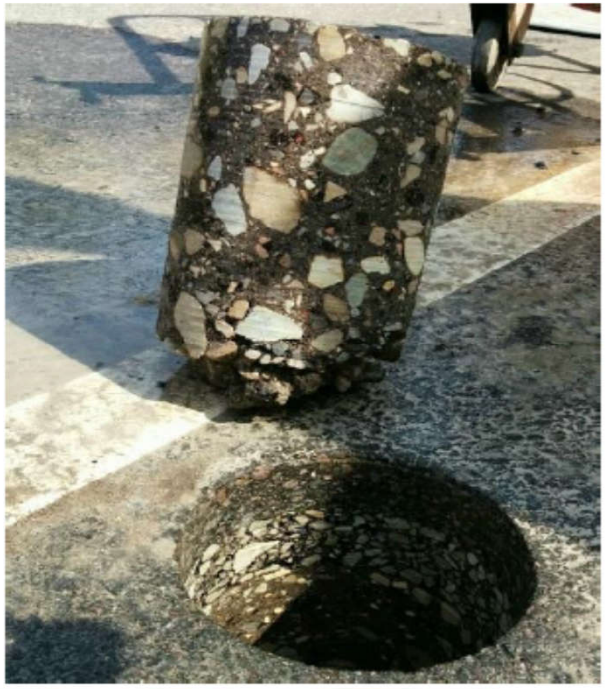
Narva-Mustajõe pilot site technical monitoring

- Stabilised layer core-sampling – compression strength measurements
- FWD bearing capacity measurements
- Pavement observation (cracks emergence)



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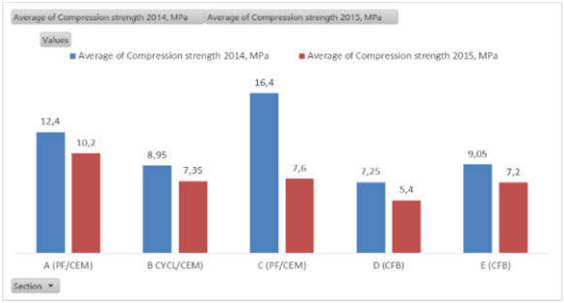
Narva-Mustajõe compression strength



Sam-ple	STA	Compression strength 2014, MPa	Compression strength 2015, MPa	Section/ structure type	UCS reduction	Average compression strength, MPa
1	1+20	11,4	9,6	A (PF/CEM)	18%	11,3
2	3+10	13,4	10,8			
3	6+00	9,4	7,6	B (CYCL/CEM)	18%	8,2
4	8+90	8,5	7,1			
5	10+25	16,4	7,6	C (PF/CEM)	54%	12,0
6	10+80	6,8	5,9	D (CFB)	26%	6,3
7	11+05	7,7	4,9			
8	16+00	9,2	6,7	E (CFB)	20%	8,1
9	16+50	8,9	7,7			

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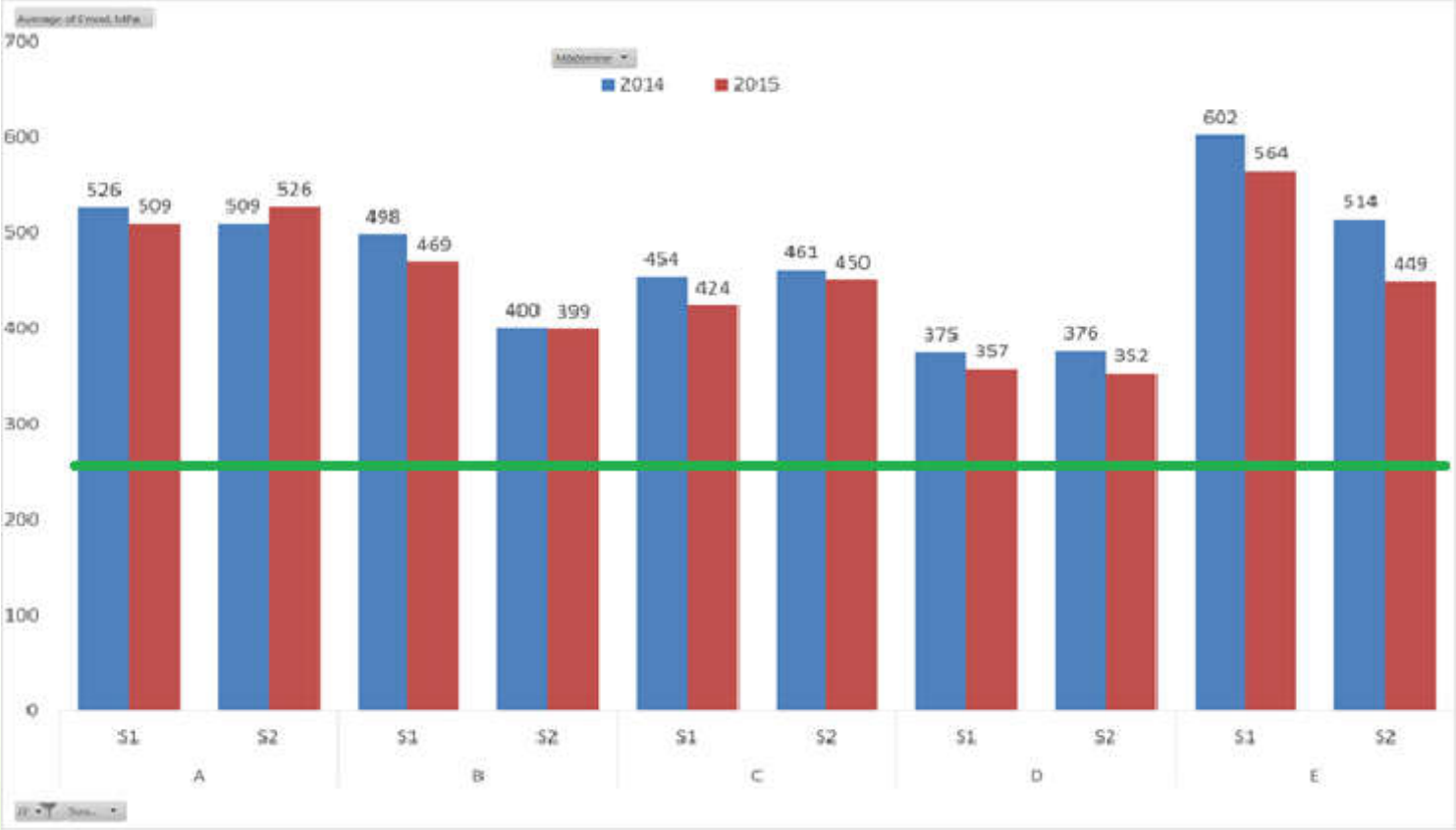
Narva-Mustajõe load bearing capacity (E-modulus), designed 260 Mpa (green line)



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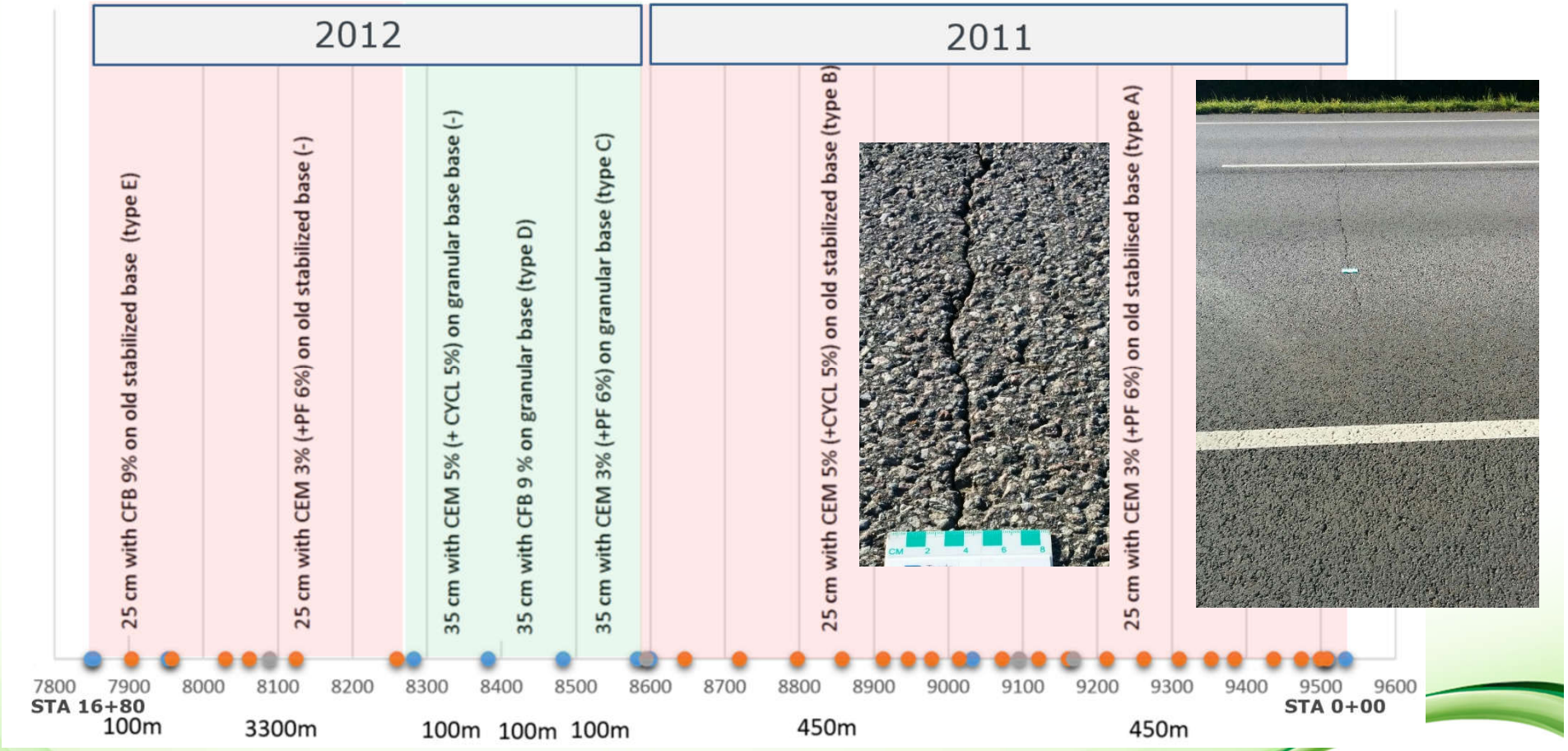
Narva-Mustajõe cracks investigations



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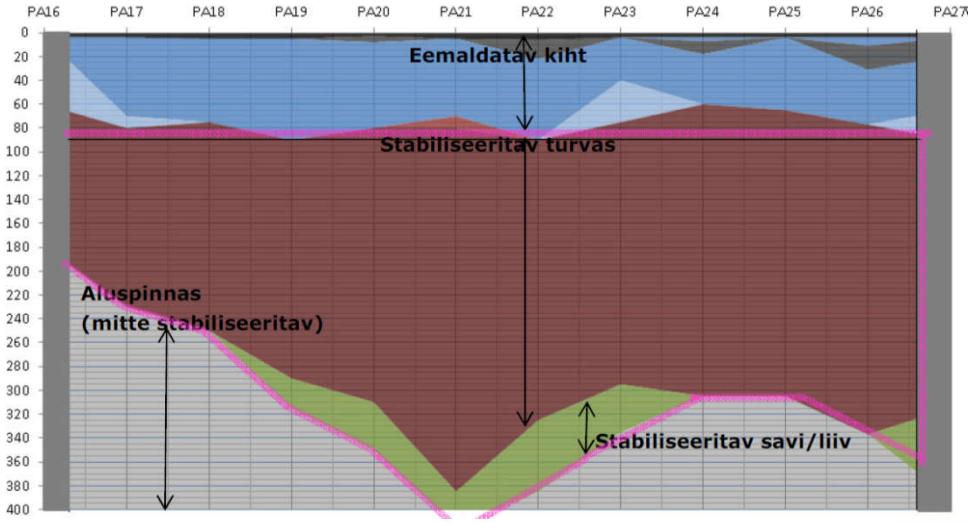
Pilot construction (2)

- Simuna-Vaiatu mass-stabilisation
  - Section length – 500 m, depth – 4 m, stabilised peat volume – 10 800 m^3



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Simuna-Vaiatu recipes

Length of the section	Mass-stabilisation recipe
90 m	Cycl 200 kg/m3 + KS 60 kg/m3
110 m	Filter PF 190 kg/m3 + KS 90 kg/m3
100 m	Filter PF 170 kg/m3 +KS 110 kg/m3
100 m	EF PF 180 kg/m3+ KS 100 kg/m3
100 m	EF CFB 200 kg/m3+ KS 80 kg/m3
	Layer stabilisation recipe
490 m	EF CFB, 9%
410 m	Complex stabilisation with cement

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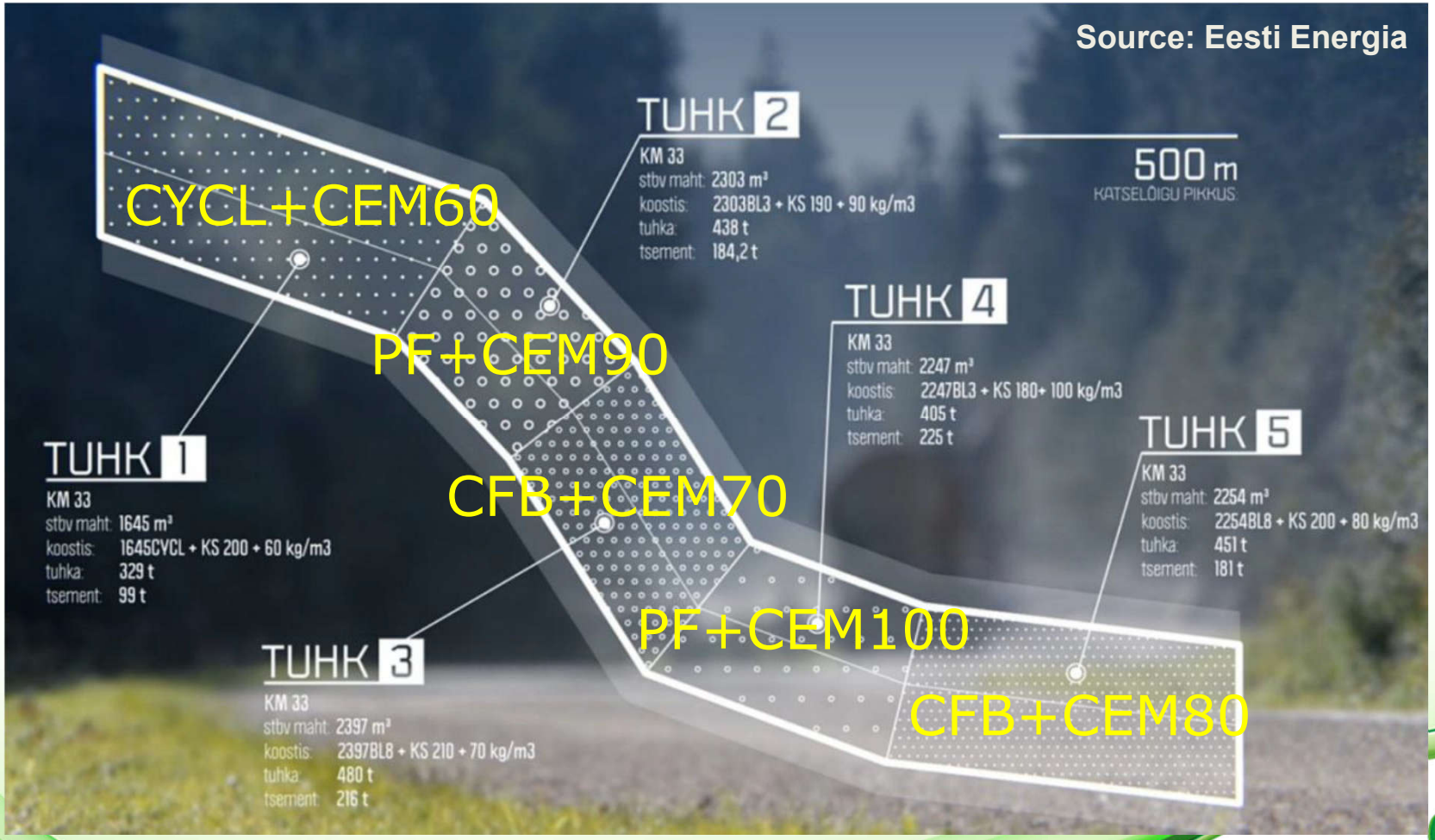
Simuna-Vaiatu sections



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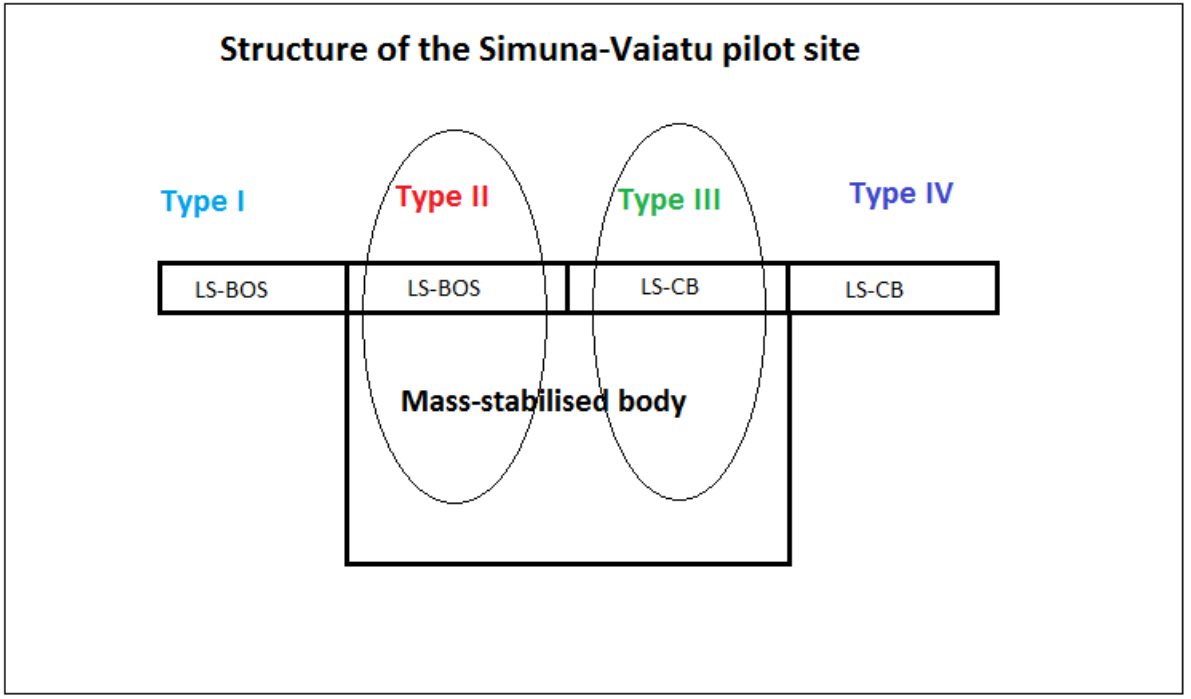
Pilot construction (3)

- Simuna-Vaiatu layer stabilisation
  - LS-BOS- layer stabilisation with OSA
  - LS-CB layer stabilisation with cement



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Simuna-Vaiatu technical monitoring

- Share strength measurements
- Structure settlement observation (settlement plates)
- Mass-stabilised body core-sampling – compression strength measurements
- FWD bearing capacity measurements

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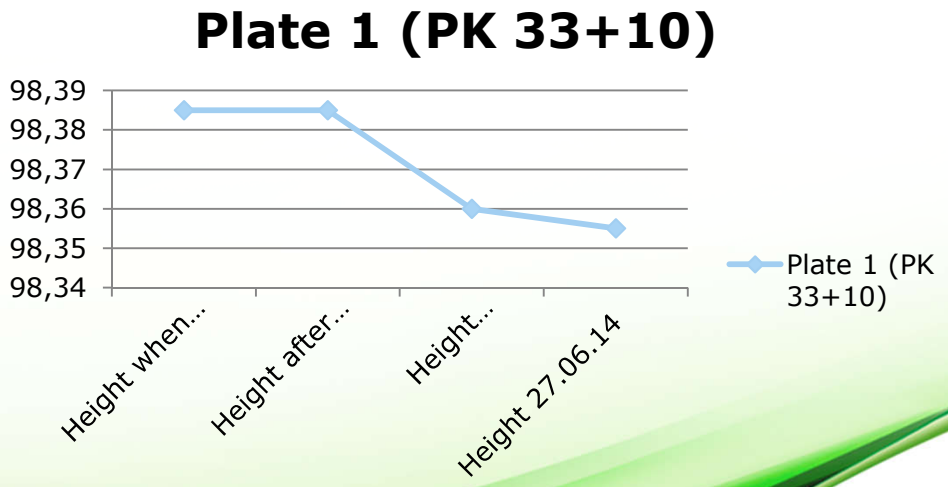
Settlement observation (settlement plates)

	Plate 1 (PK 33+10)	Plate 2 (PK 34+10)	Plate 3 (PK 35+10)	Plate 4(PK 36+10)	Plate 5 (PK 37+10)
Height when installed	99,449 (25.07.2013)	99,584 (19.08.2013)	99,620 (25.09.2013)	99,476 (30.08.2013)	99,374 (23.09.2013)
Height after cutting the pole	98,385 (27.09.2013)	98,817 (12.09.2013)	98,865 (27.09.2013)	98,732 (27.09.2013)	98,558 (27.09.2013)
Height 08.01.2014	98,36	98,793	98,865	98,685	98,52
Height 27.06.14	98,355	98,775	98,86	98,698	98,535



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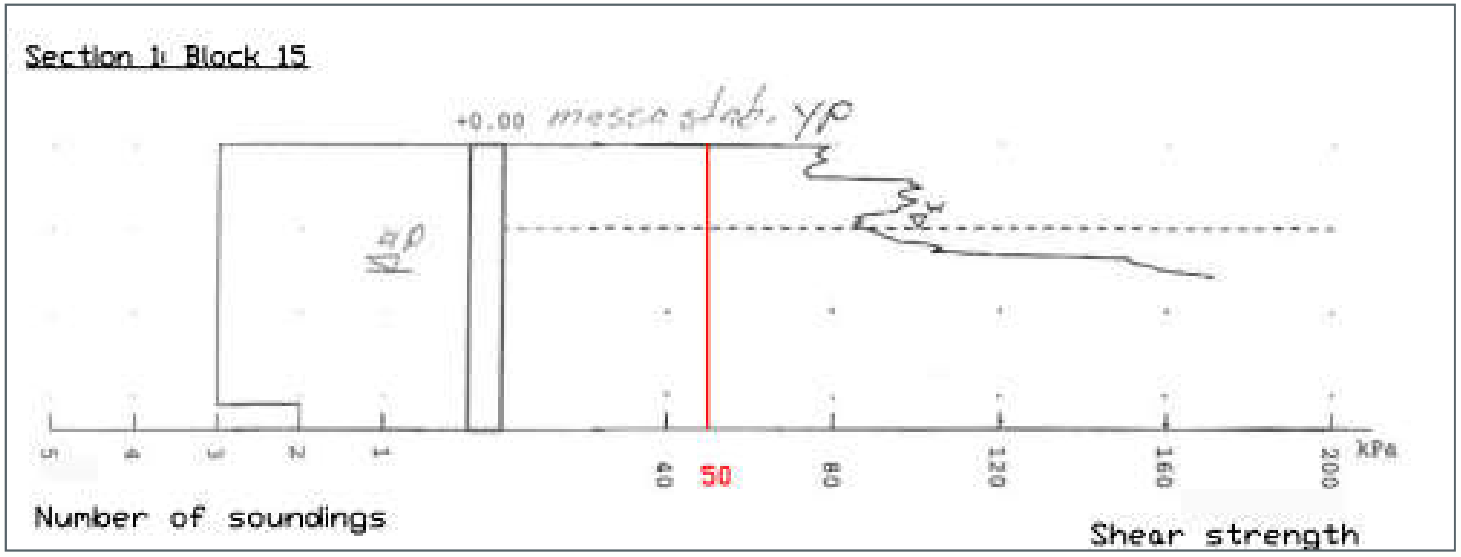
Share strength measurements

Designed vane shear strength – 50 kPa



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Simuna-Vaiatu mass-stabilised body compression strength

Sample	Water content, %	Compression strength, kN	Section/ structure type	Average compression strength, kN	Average compression strength, MPa
1	160,2	0,25	34+00	0,29	0,03
2	92,5	0,40			
3	58,0	0,33			
4	89,9	0,20	34+65	0,21	0,02
5	68,9	0,22			
6	107,5	0	36+00	0,04	0,00(0,004)
7	85,7	-			
8	89,1	0,07			
9	132,1	0,09	37+00	0,12	0,01
10	66,5	0,14			

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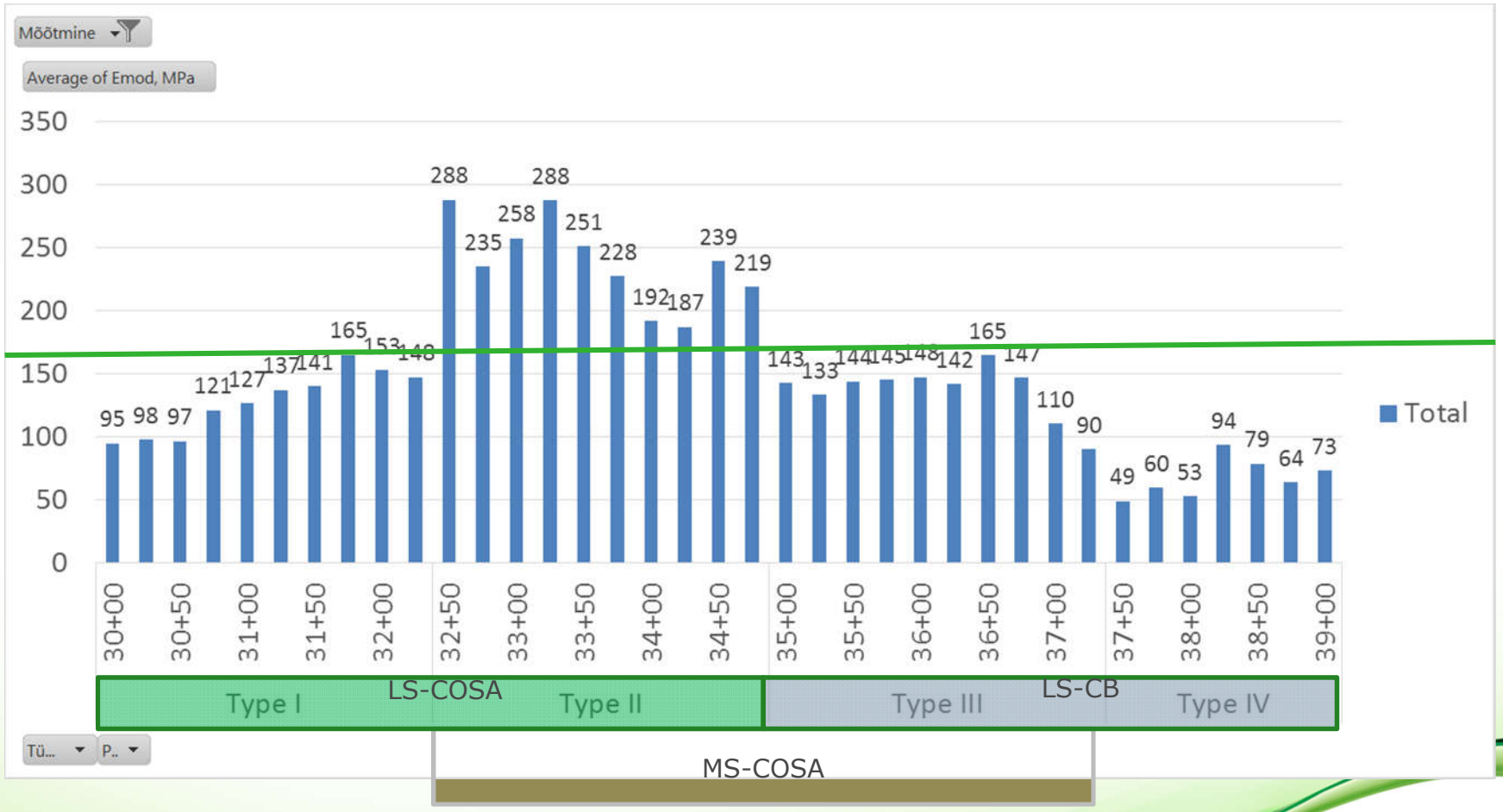
Simuna-Vaiatu load bearing capacity (E-modulus), designed value 169 Mpa (green line)



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Summary of technical monitoring results (1)

- Simuna-Vaiatu
  - bearing capacity of mass-stabilised section exceeds the one of peat significantly, no difference between sections (between OSA)
  - High compression and tensile strength of the lab samples (2,4-8,1 MPa) for layer stabilisation, less OSA could be used
  - High load bearing capacity (1.5-2 times higher than designed)
  - Load bearing capacity values chamges depending on the yaer season (water content)

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Summary of technical monitoring results (2)

- Narva – Mustajõe
  - All subsections have high load bearing capacity
  - Compression strength 2015 was 5,4 – 10,2 Mpa
  - 2015 many transversal cracks (24), only in these sections with old stabilisation underneath

CONCLUSIONS

1) To understand long-term performance, monitoring of mass-stabilised and layer stabilised sections is needed
2) Layer stabilisation has been in tests for ca 5-6 years now and there's no evidence that performance of layer stabilisation would be weaker than the one of other stabilisation methods

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Pilot sites environmental monitoring

Surface water, soil and flora observations

- Measurements
  - Anions (chloride, fluoride, sulphate)
  - Trace elements (incl priority substances Pb, Hg, Cd, Ni)
  - Indicative measurements (pH, electric conductivity, t)
  - Visual observation (plants growing)

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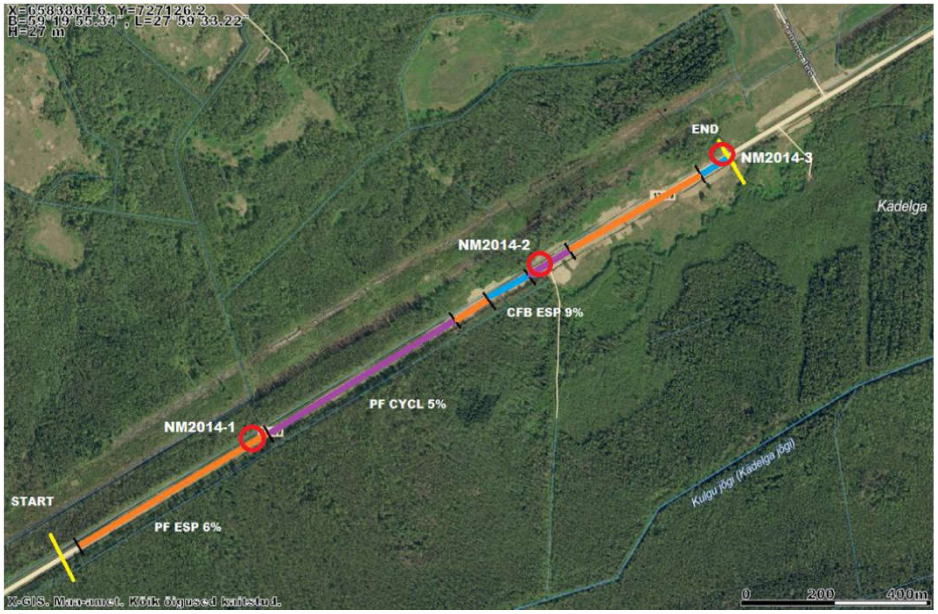
Soil sampling

The content of all selected trace elements in soil samples is below national environmental quality limits and the road construction has not affected the soil quality



Narva-Mustajõe

Simuna-Vaiatu

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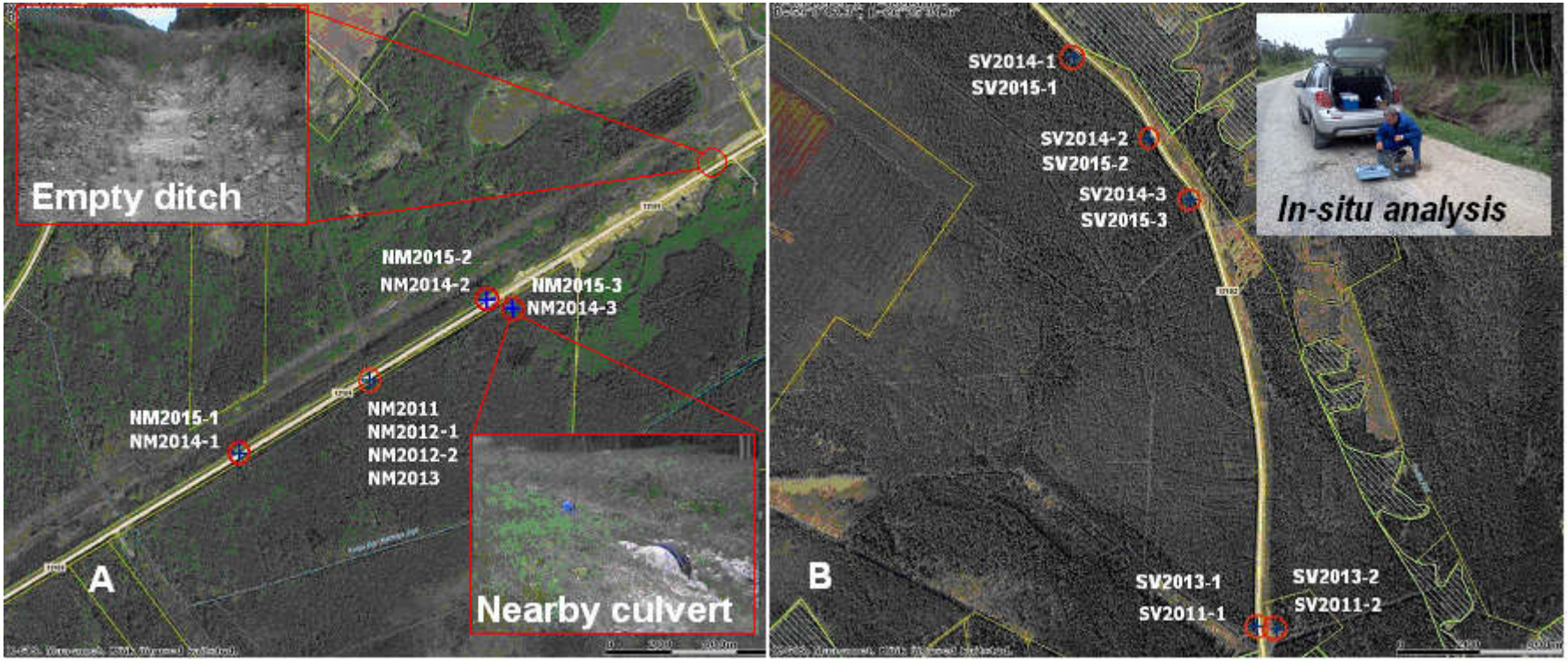
Water sampling



Narva-Mustajõe

Simuna-Vaiatu

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Water sampling results

- The content of priority hazardous metals, Hg and Cd is below limit of detection (LOQ) in all surface water samples.
- The road construction has not affected the natural level of pH or electric conductivity of surrounding surface water.
- The content of chlorides and fluoride is similar to natural background level or with the observations made before road construction.
- Content of lead was below LOQ in all water samples;
- Traces of nickel were found close to detection limits in both pilot sections and is considered as a natural background and is not caused by road construction.
- Among hazardous substances fluoride, arsenic, barium, copper, zinc and baarium were detected. All the substances concentrations were with the national legislation besides Ba. The content of Ba was above the limit value, but below the natural content of Ba in the pilot section area.
- Sulfate rise was observed at N-m pilot section

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Dissemination, project webpage www.osamat.ee

Grant Agreement LIFE09 ENV/EE/000227 OSAMAT deliverables	Planned	OSAMAT project
Outputs of the dissemination action	**amount, it**	**amount, it**
Press releases	4	38
Articles in a professional and national magazines	4	4
Conference posters and papers	4	17
Slides-presentations After-LIFE	2	2
After-LIFE Communication Plan	1	1
Layman's report	1	1
Dissemination report	1	1
Guidelines for European Practice	1	1
DVD presentation about the project, its methods and results	1	2
International Conference and Workshop	1	1
Webpage	1	1
Notice boards	2	2
Total	**23**	**71**

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Dissemination: OSAMAT International Conference and Workshop

- 104 participants, 12 speakers
- Presentation of the energy production by-product use in road construction in Finland, Germany and Greek.
- Narva Power Plants visit and Workshop

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Project results (1)

- Construction mixtures recipes with OSA to use OSA in road layer construction (layer stabilisation) and in road embankment construction (mass-stabilisation).
- Guidelines for European Practice – instruction for the constructor how to use OSA in road construction (tested applications).
- Laboratory and field test results of environmental monitoring have proved OSA safety to environment and human health (in tested applications). Documentation (results, reports) is a valuable input data for further OSA projects and standardisation.
- Laboratory and field test results of technical monitoring have proved OSA suitability and availability of cement substitution as binder material for road construction. Documentation (results, reports) is a valuable input data for further OSA projects and standardisation.

Project results (2)

- Due to dissemination actions the OSA was introduced as binder material for road construction in Europe. As a result important collaboration with Europe ECOBA and big cement producers has been started. OSA has been testing in Lithuania, Finland and Sweden to use in mass-stabilisation.
- Due to dissemination actions the perception in Estonia to OSA has been changed. OSA is considered to be used in 3 project in Estonia (Rail Baltic railway construction, Tallinn-Tartu highway construction and Tootsi wind park).
- LCC studies and later calculation (for Estonian projects – see the previous clause) seems to show that OSA use can bring economic benefits.

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Mass-stabilisation projects: 5 year perspective

- Estonian projects ~ 300 000 t of OSA
- Outside Estonia projects ~50 000 t of OSA

Client approach

Step1
- material characterisation according to client needs
- testing

Step 2
- legislation, transportation possibilities and economics

Step 3
- pilot tests
- investments, production

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After –LIFE action plan

After-LIFE action	Details of the action	Period
Webpage update www.osamat.ee	1) The webpage update with After-LIFE action results	2017-2020
Pilot sites (N-M and S-V) technical and environmental monitoring	**1)Environmental monitoring:** surface water sampling and soil sampling 2 a year	2018;2020
	2)Technical monitoring: defects analysis; load bearing capacity, samples compression strength measurements	2018;2020
Dissemination	**1)** Participation in the conferences (at least in 2 for four year period)	2017-2020
	2) Layman's report and booklet dissemination at conferences, meetings	2017;2018
	3) Articles production: at least 1 science article and 1 article at a magazine	2017-2020

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Thank you!

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