14.15 – 14.45	Possibilities to use recycled aggregates in road construction works, examples from Estonia *Ott Talvik, Tallinn University of Technology*
14.45 – 15.05	Utilization of by-products of limestone industry in road construction *Sven Sillamäe, TTK University of Applied Sciences*
15.05 – 15.30	Overview of the research on use of oil-shale mining waste and oil shale combustion ash *Marek Truu, Technical Centre of Estonian Roads*

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10 years of research on oil-shale ash and mining waste aggregate for roads

International Conference on Roads & Recycling
October 9, 2014 Tallinn

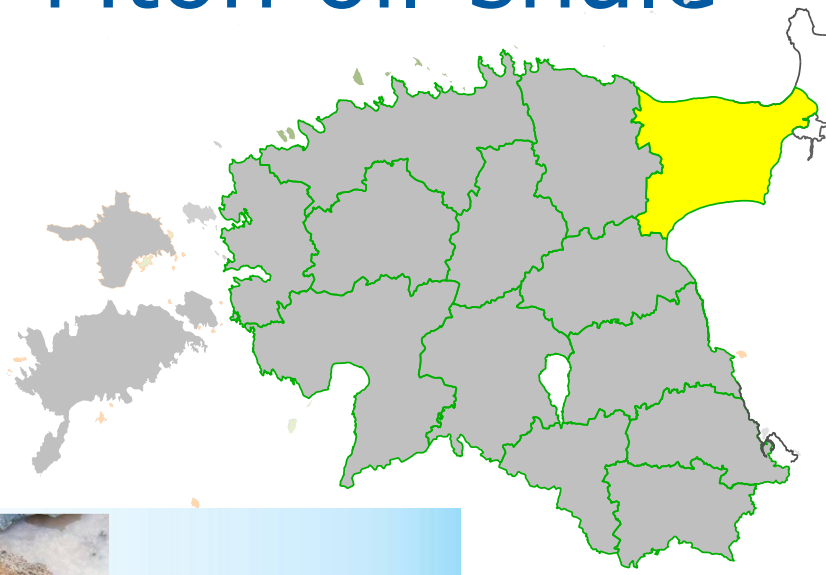
Marek Truu
R&D Department | Road Research Project Manger
TEEDE TEHNOKESKUS /TECHNICAL CENTER OF ESTONIAN ROADS
09/10/2014

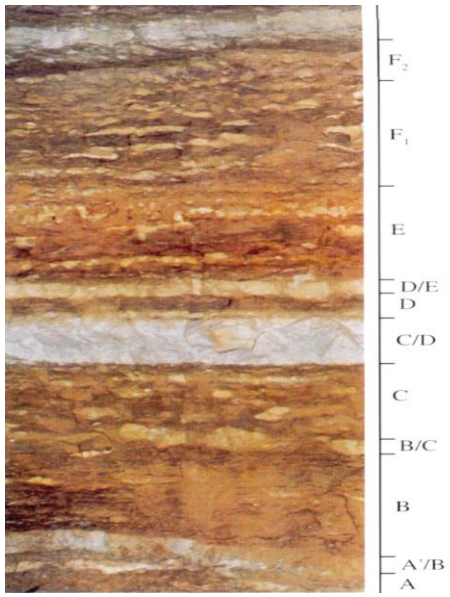
OSA & MWA

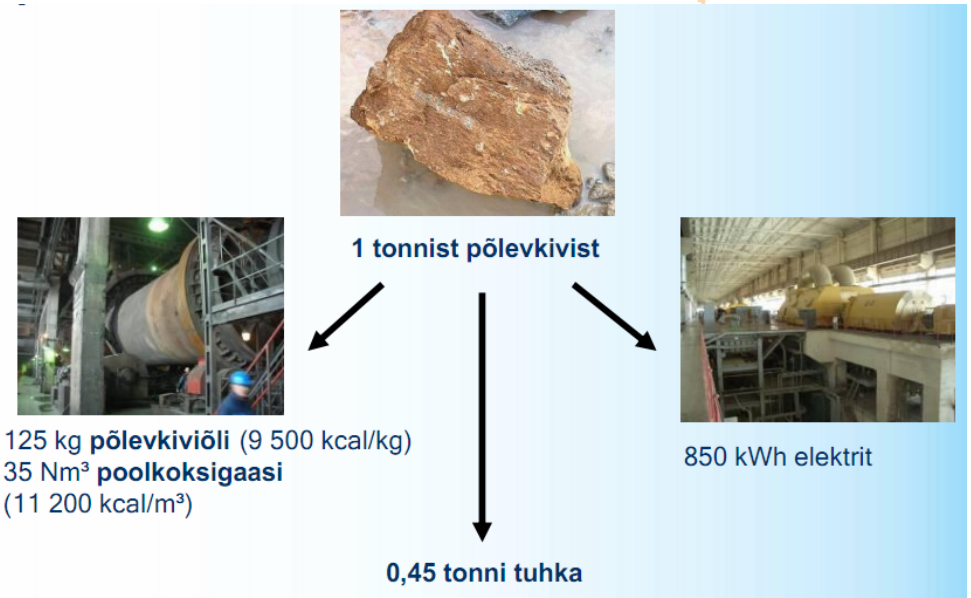
- **Mining waste aggregate (MWA)** – limestone aggregate from between the oil-shale layers but sometimes also from upper layers of open mining is countered
- **Oil shale ash (OSA)** – ash from combustion of oil-shale, consisting of fine non-burnable particles having cementing properties. Many different combustion types lead to different chemical composition and properties of these ashes and with filters effective separation of fractions with different properties (activeness) can be achieved

“Production” from 11 Mton oil-shale

- Ash - ca 5-7 million tons
- MWA – ca 4-5 million tons







Picture source: Eesti Energia

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Ash research history

- 2005 Ash-stabilised 30-40 years old pavements were reviewed, compression strength up to 30 MPa
- 2008-2011 Different new ashes were tested with different aggregate mixes and soils with German engineering company, test section with sand stabilisation
- 2012-2013 Test section with a use of MWA and OSA in Ojamaa (VKG)
- 2014-2015 Research on ash-stabilised road sections Simuna-Vaiatu and Narva-Mustajõe (EE)

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Built ash stabilised pavements

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2005 OSA study results...

- Some OSA-pavements had still acceptable condition, where thickness > 10 cm – compression strength 20…34 MPa
- In many cases the defects were found, main causes:
  - Too much and varying OSA content (15…25%)
  - Unevenness of OA, high/varying CaO_{free} content: 5-25%
  - Primitive technology – unhomogenous mix and varying thickness
- With today's technology everything is possible …

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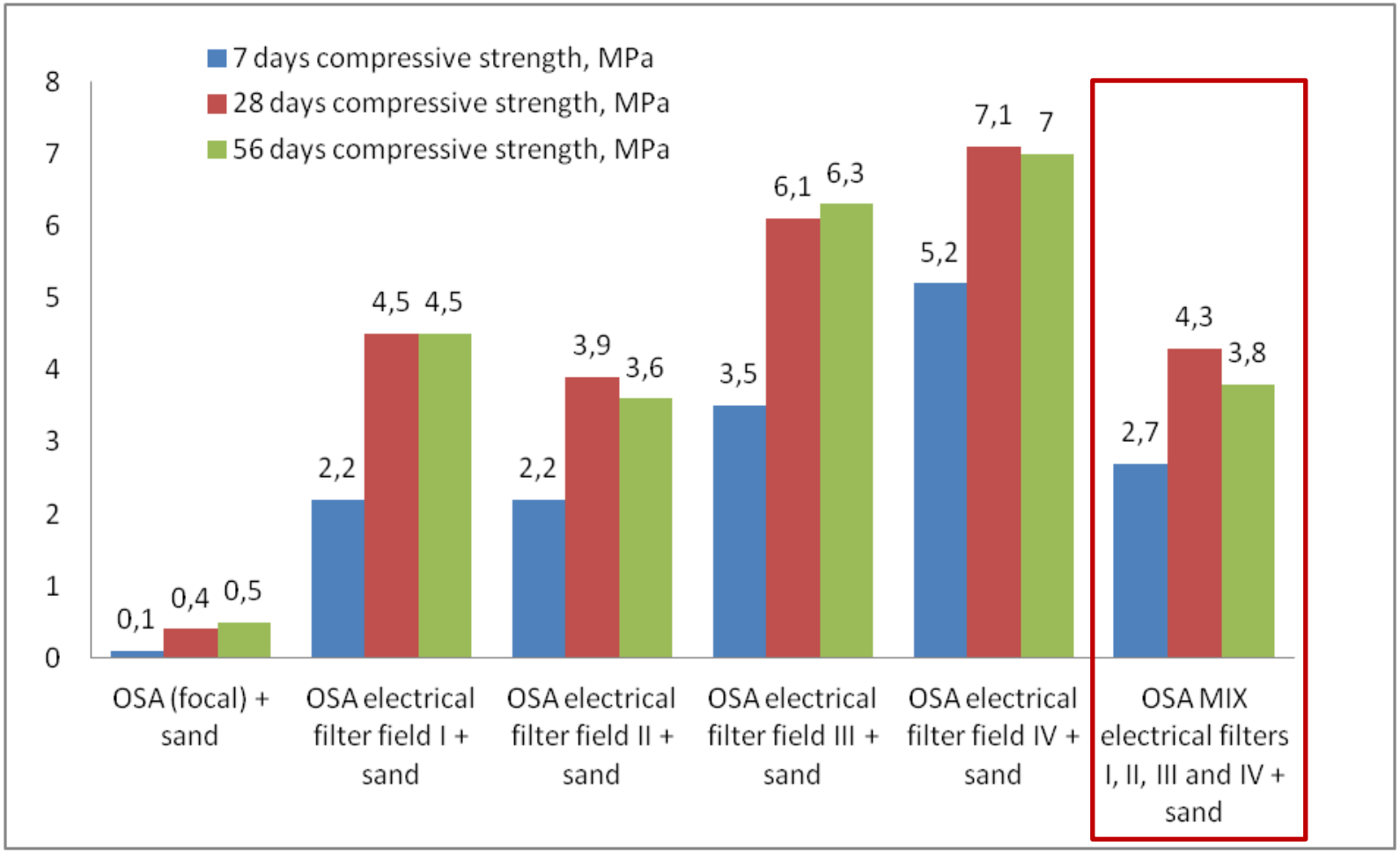
Different OSA-s (study 2009)



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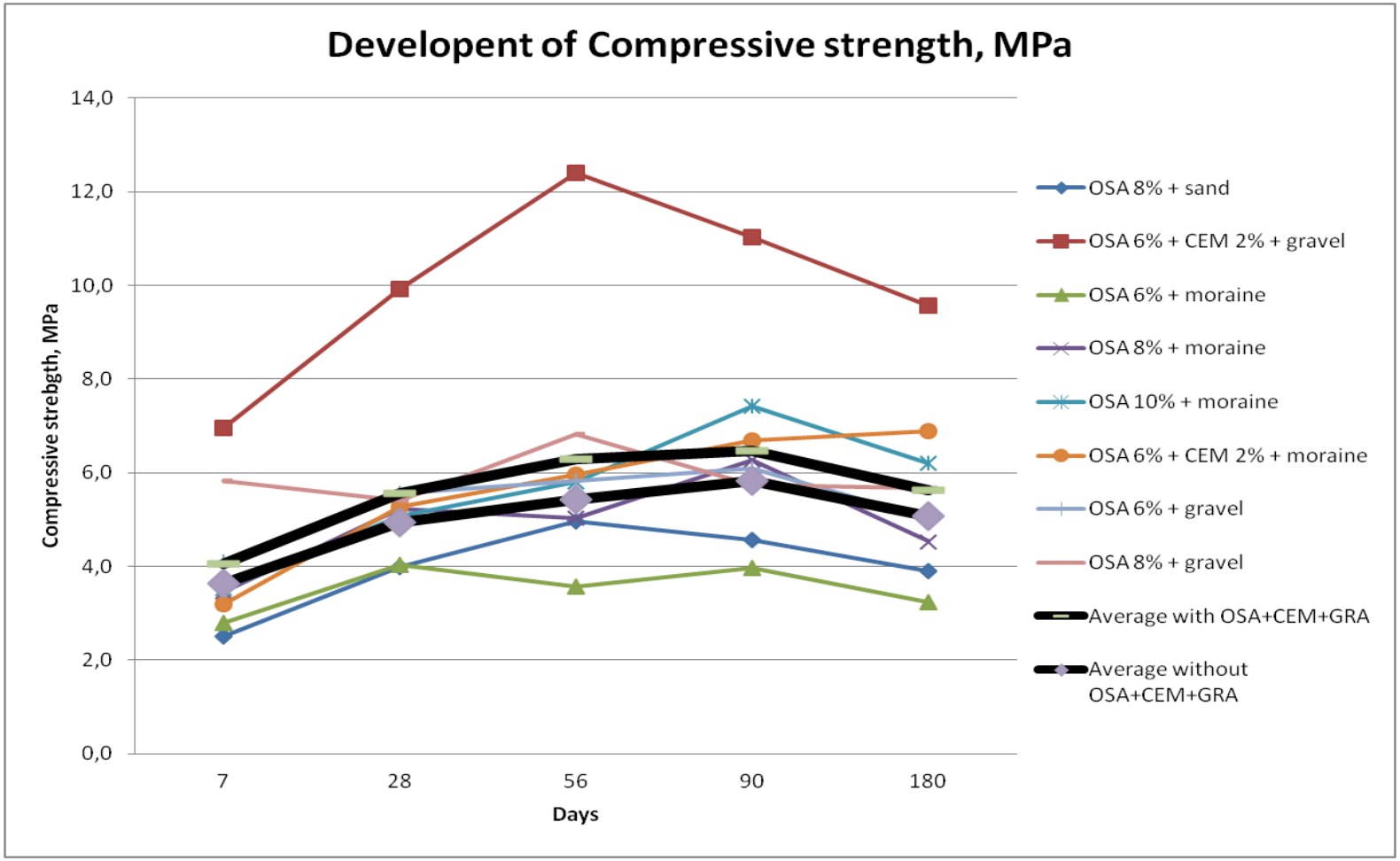
Compression strength (study 2009)



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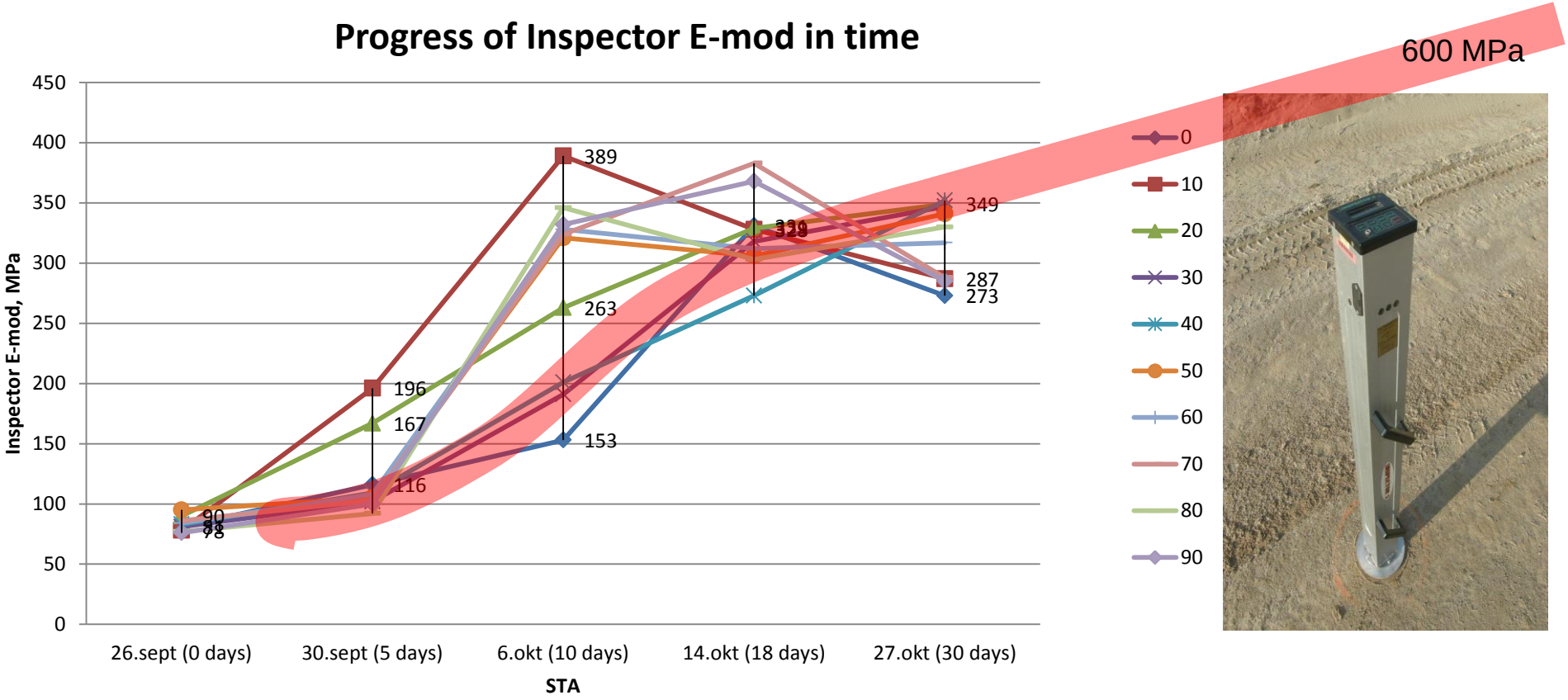
Strength of sand ash-stabilisation



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Research on using ash...

- Simuna-Vaiatu
  - deep stabilisation with ash and cement
  - ash stabilisation of pavement
  - stabilisation with bitumen and cement
  - sampling and testing: compressive strength, water susceptibility TST, bearing capacity FWD
- Narva-Mustajõe
  - 5 different pavement ash stabilisation types
  - testing compressive strength, bearing capacity FWD

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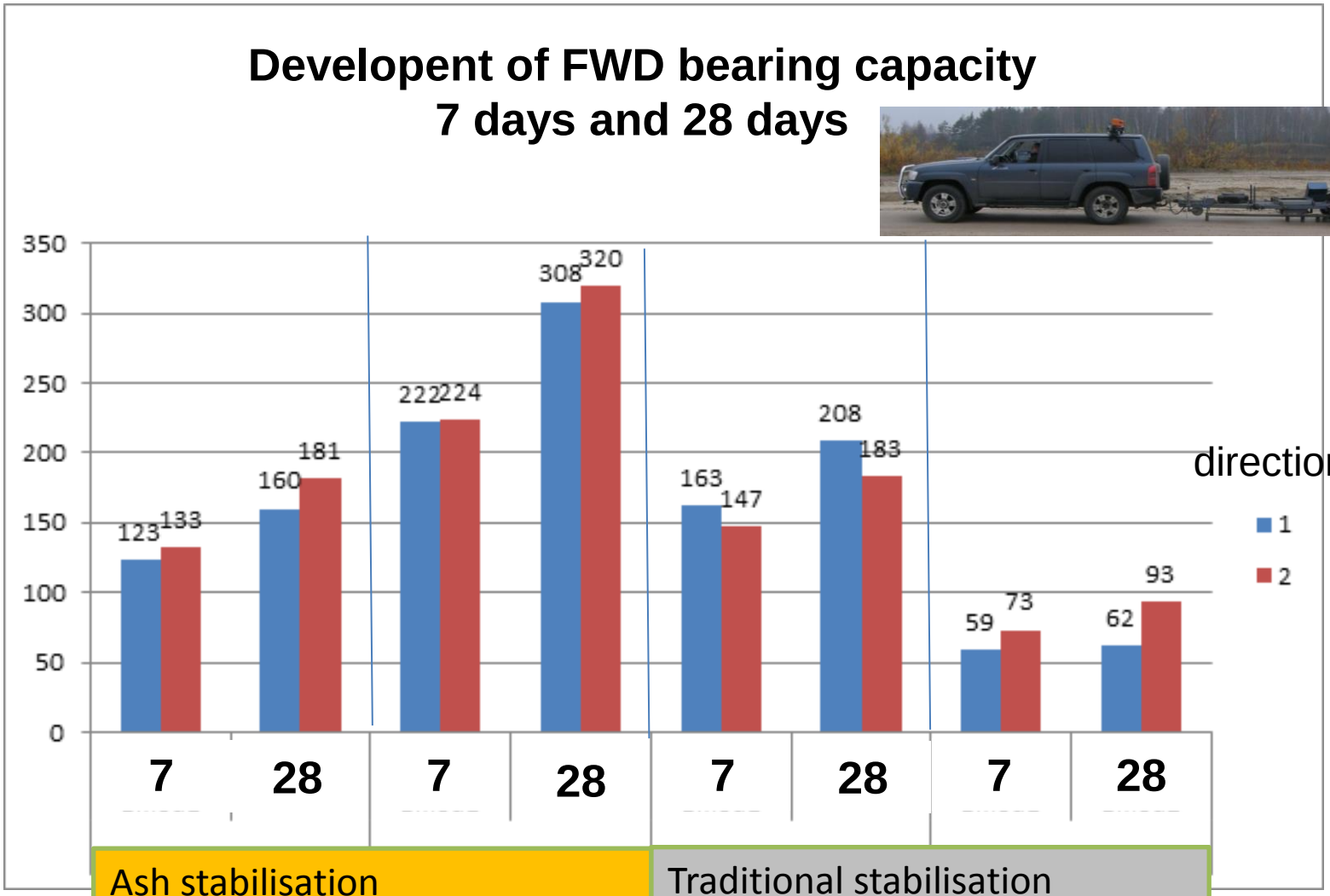
Strength of Simuna-Vaiatu (2014)



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Deep stabilisation properties

- Average compression strength 0,2 MPa
- Average water content 150%

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Strength of Narva-Mustajõe (2014)

Section	Sample	Stabilisation type	Compression strength, MPa
0+50–5+00	1&2	25 cm new aggr + EF BL3 OBT 6 % + CC 3 % Below old stabilised structure	12,4 (9,0@2011)
5+00-9+50	3&4	25 cm new aggr + CYCL 5 % + CC 5 % Below old stabilised structure	8,9 (2,0@2011)
9+50-10+50	5	35 cm new aggr + EF BL3 OBT 6 % + CC 3 % Below granular old structure	16,4 (4,5@2012)
10+50-11+50	6&7	35 cm, EF BL11 NBT 9 % Below granular old structure	7,2
15+80-16+80	8&9	25 cm EF BL11 NBT 9% Below old stabilised structure	9,0

Source: Narva-Mustajõe Pilot Report

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Aggregates research history

- 2009 Study to compare different limestone and dolostone aggregates' freezing resistance
- 2010 Overview of problems and needs in research of limestone aggregate for road base course
- 2012 Research of condition of limestone base courses on 30-40 year old roads
- 2014-2015 Research on methods to improve limestone incl. the one from mining waste by impregnation and hydraulic bond

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Why do we avoid MWA in base

- MWA is a relatively weak aggregate with LA>35 and poor freezing resistance and poor shape
- Weak means we don’t know good enough technology to guarantee the needed particle size distribution after building
- Poor freeze-thaw resistance means that if we let the water into the structure from up or down, the material gets finer fast and looses strength
- Poor shape means we don’t use effective enough technology to place the aggregate without polishing the corners and getting round

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What’s the problem with water?

- We have small to serious water problems on most (90%?) of road network, specially on smaller roads - high groundwater and silty soils – water gets high below pavement plus rainwater may get there too through pavement defects or shoulders, specially on late winter with melting snow
- Freezing depth down to 2-3 metres in Estonia + several freeze-thaw cycles

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What can we do about?

- To maintain better shape and protect form breaking down aim for less interaction with aggregate on road, using of pavers instead of graders
- Build roads in a way to avoid excess load from traffic and water
- Lets try to improve the freezing resistance performing laboratory tests by avoiding/reducing water penetration into particles:
  - impregantion (bitumen, cement etc)
  - stabilisation (hydraulic bonding with bitumen cement ash, lime etc)

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Study of old limestone base courses

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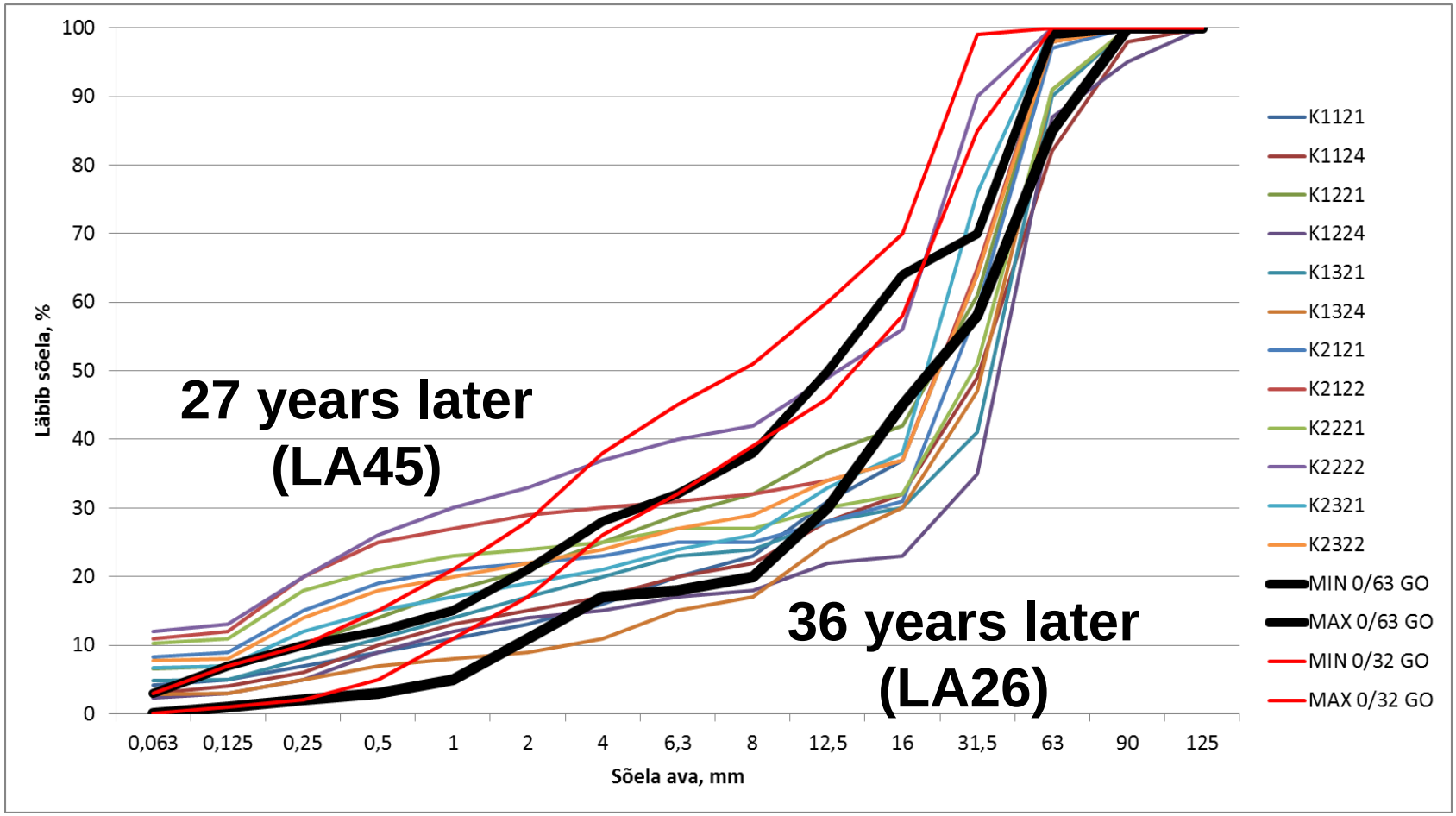
The limestone under asphalt...



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… from weak aggregate …

… performs well!

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Research on MWA improving...

- 5 MWA limestone aggregates to compare with
- 5 reference limestone aggregates
- 7 agents for impregnation
- 4 types of stabilisation (ash, cement, lime, KS)

- Tests ongoing... results available in spring 2015

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Conclusions

- Both MWA and OSA perform well in certain preconditions
- Properly selected ash can be used to strengthen:
  - road base (incl MWA)
  - soils
  - weak soils
- MWA widely used already
  - better performance needed to resist freezing resistance
  - "gentle" construction methods may be needed to maintain shape of aggregate

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THANK YOU!

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