



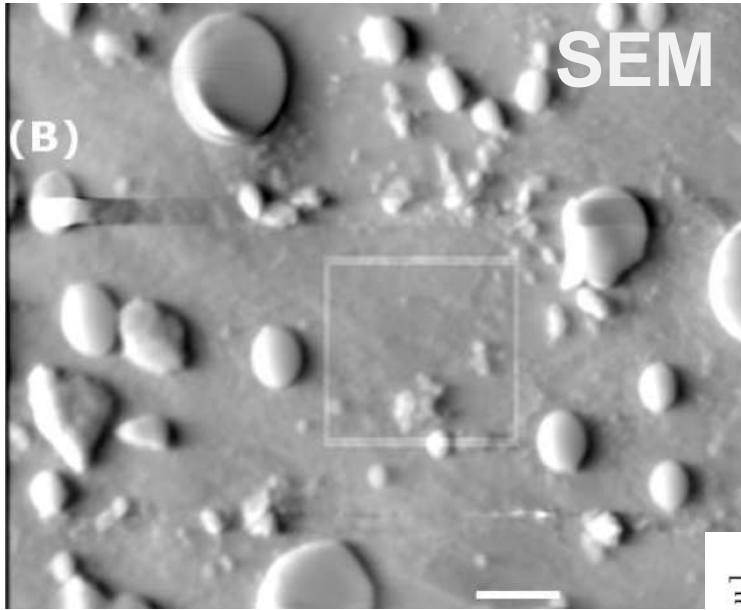
# Evaluation of REMIX type maintenance technique of asphalt roads with respect to road's history

Michalina Makowska, M. Sc.

# Outline

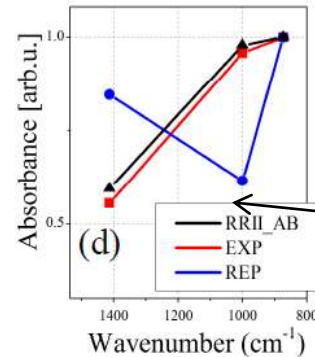
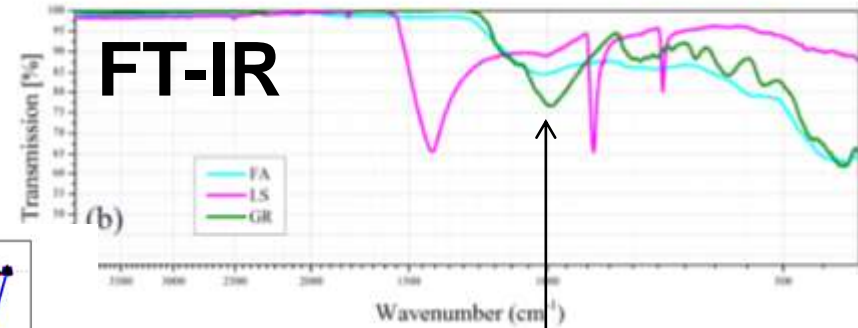
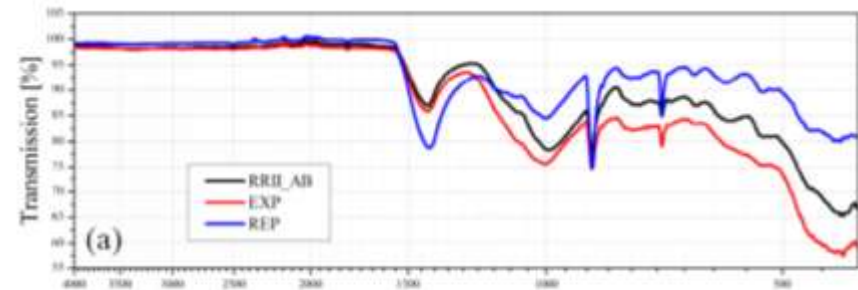
- **1. Ring Road II phase 1 – conclusion**
- **2. Ring Road II phase 2 – what have we learnt**
- **3. Background for REM studies in Finland**
- **4. My project goals and plan (outline)**
- **5. Work Package one – sampling and experiences of REM on VT1.**

# Filler influences compaction, aging characteristics and moisture susceptibility of Asphalt Concrete



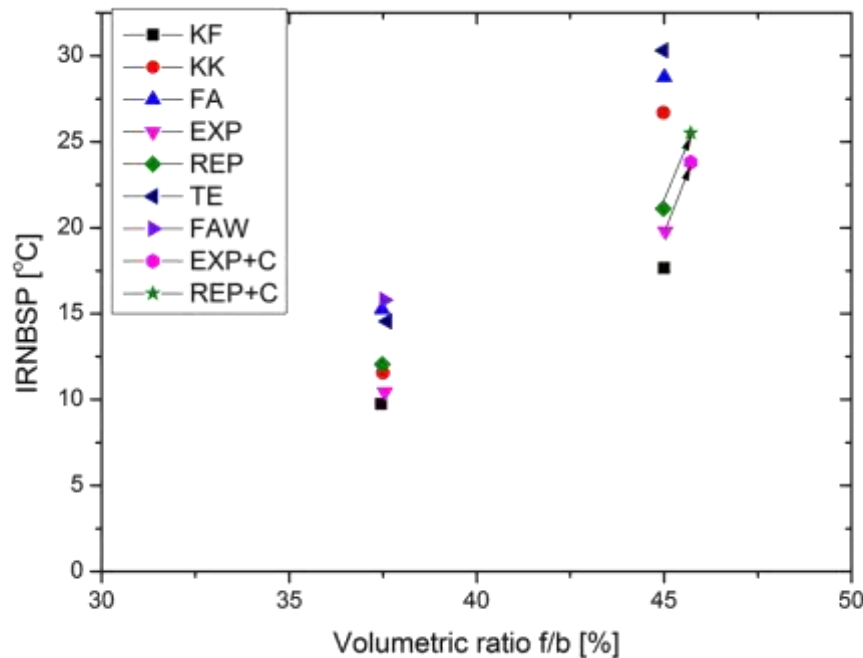
Moisture susceptibility =  $f(\text{SiO}_2)$

ASTO, 1991)



SiO<sub>2</sub>

# Filler affects to the stiffening and compaction – air voids affect to strenght

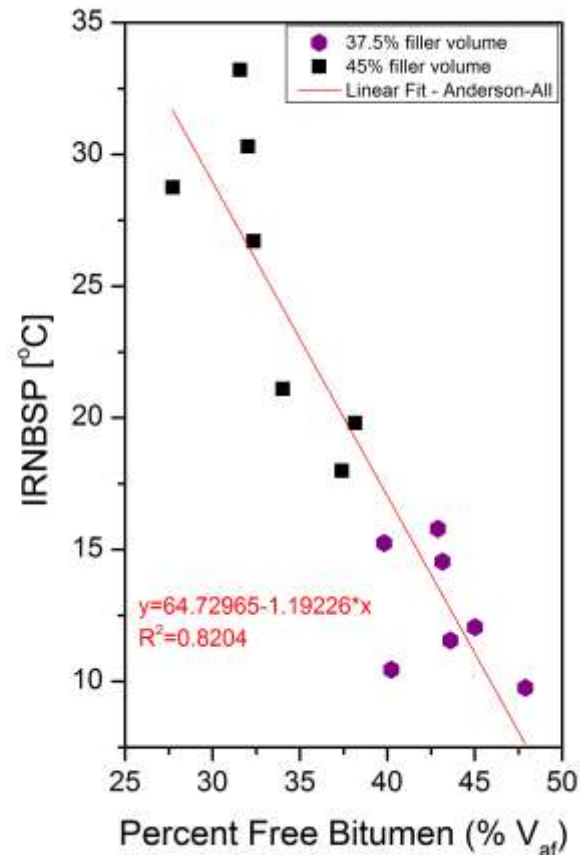
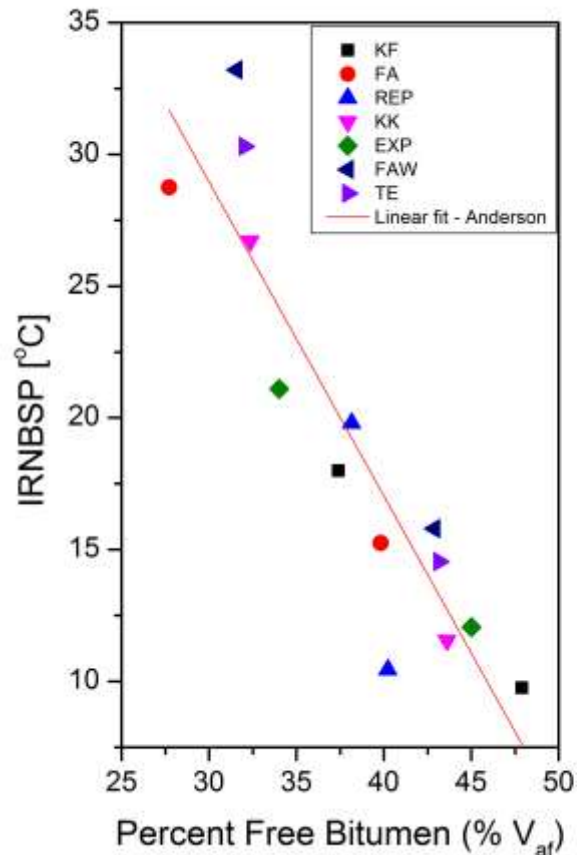


Volumetric representations are not helpful

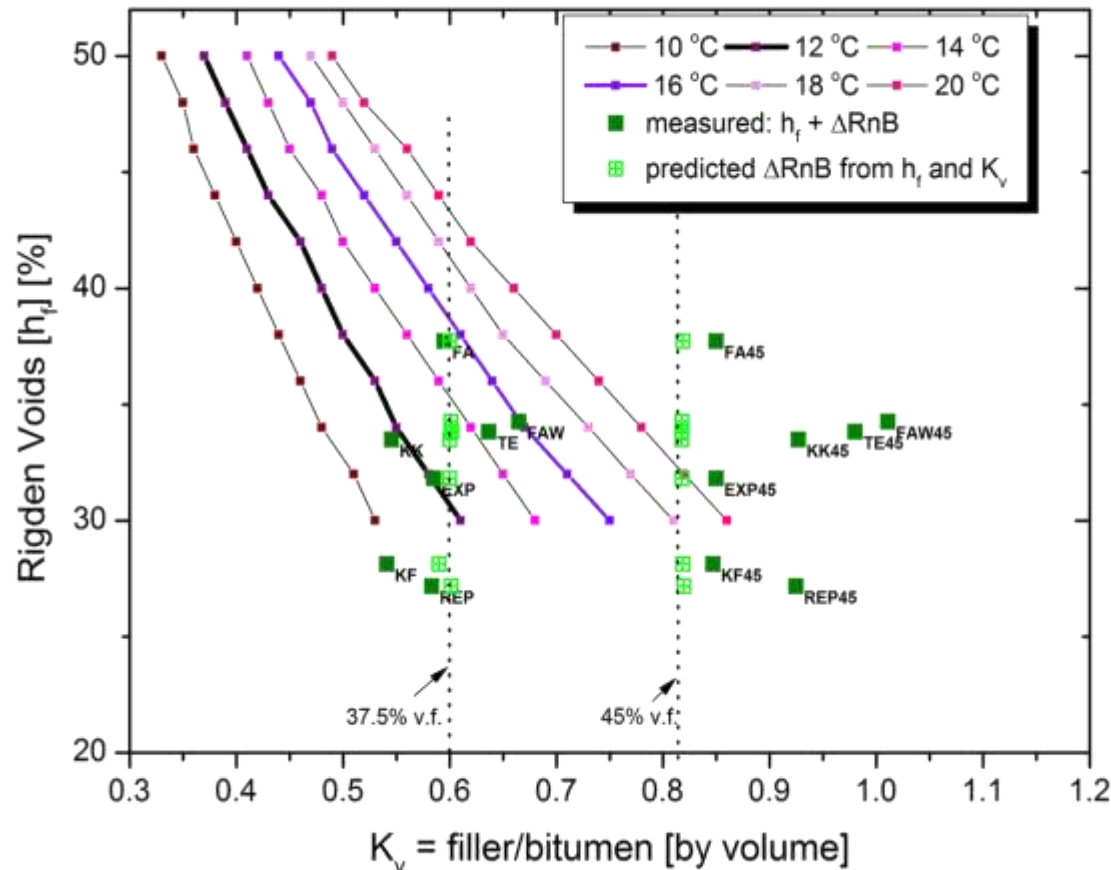
15°C range is a bad prediction

Filler → <0,125 mm  
Bitumen 70/100

# Utilizing Anderson's concept of Percent Free Bitumen a better prediction is found (5-10°C)

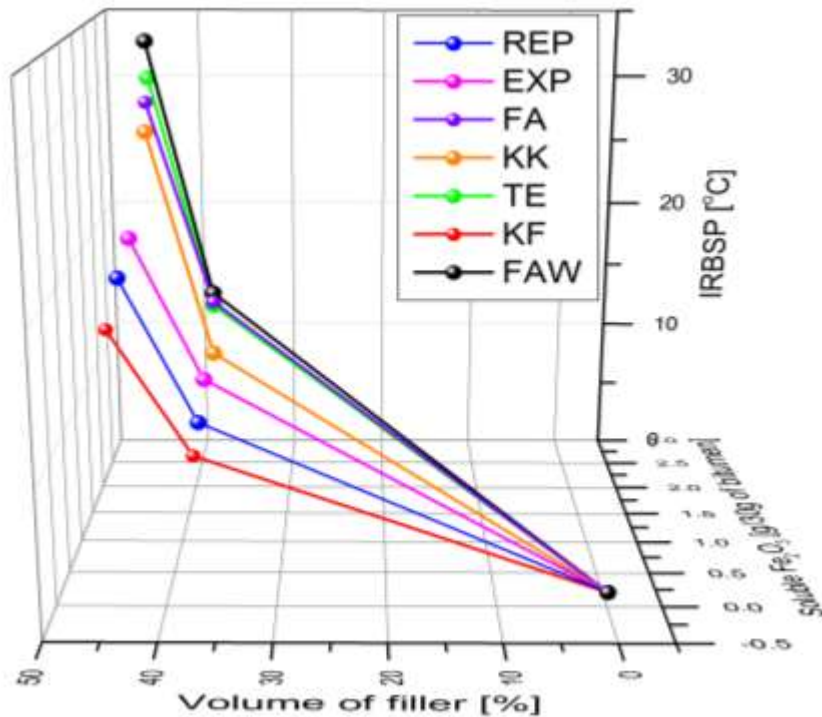


# Belgian specification method of predicting $\Delta R\&B$ is more accurate, but only within $K_v=0,6$

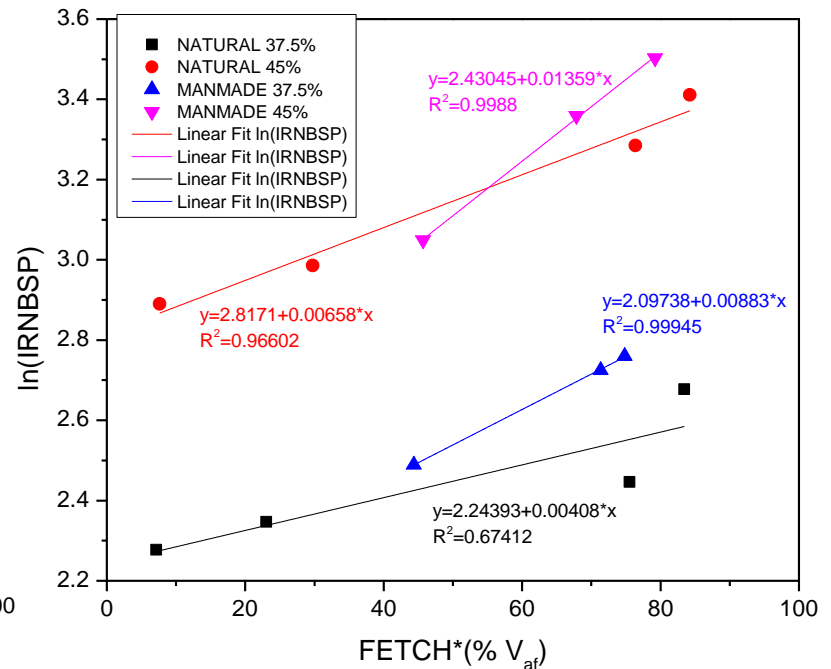
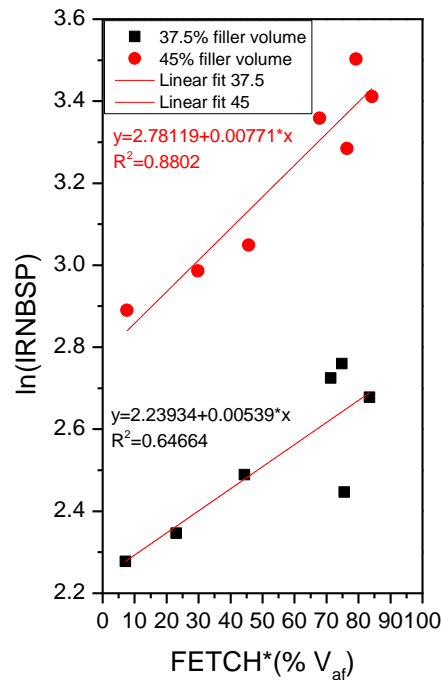
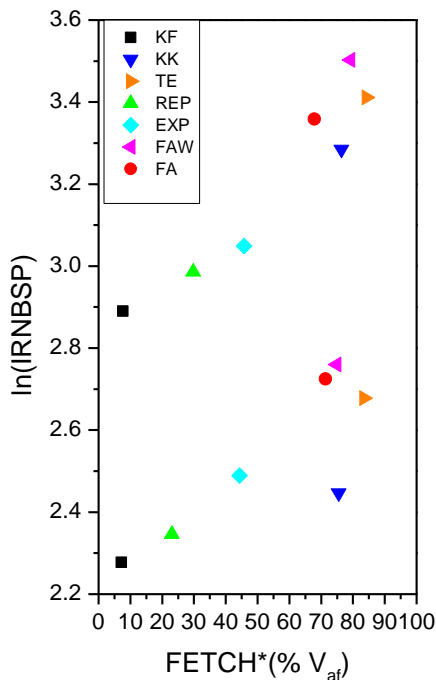


Only for standard samples of exactly 37,5% filler by volume

# The etchable iron content was found to be a new parameter

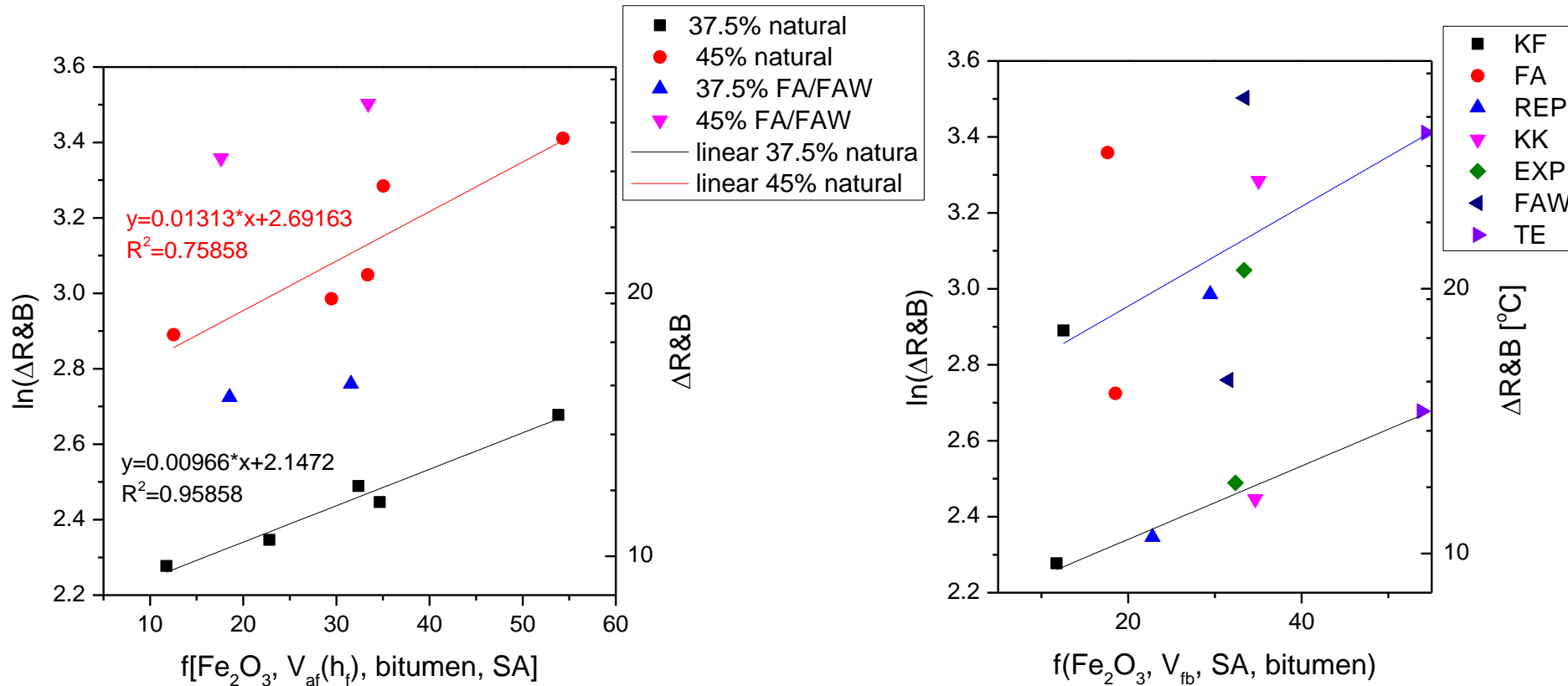


# Stiffening is dependent on the etchable iron content (FETCH), but not only

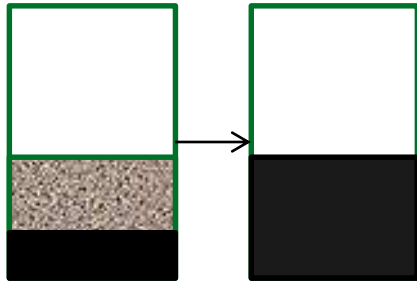




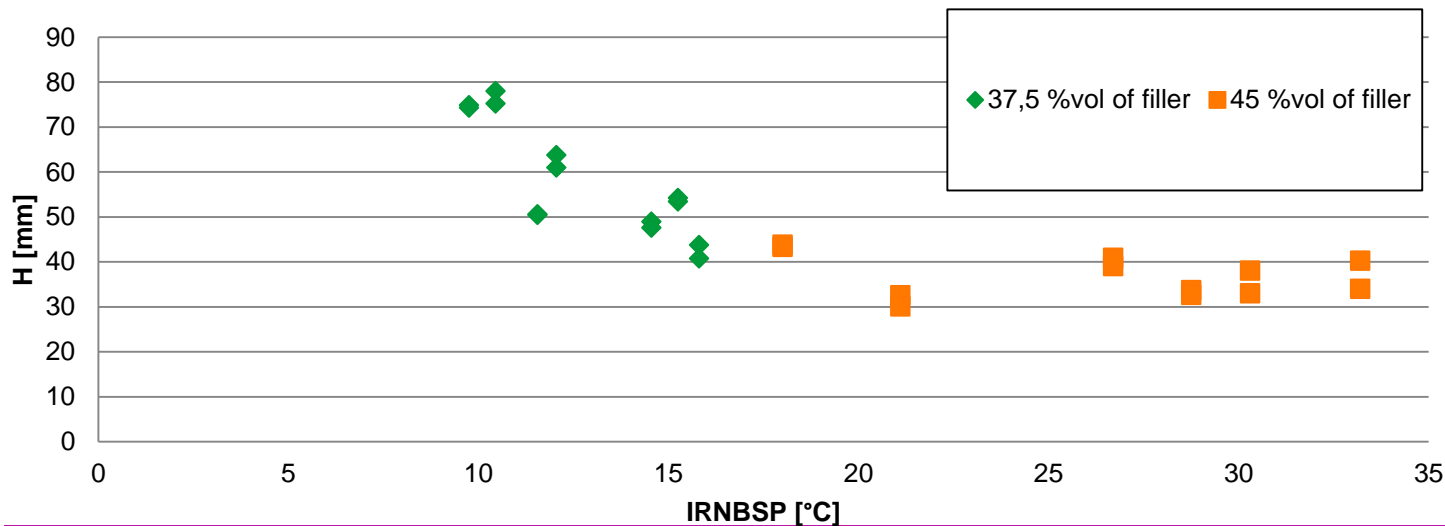
# Mastic stiffening depends on voids in mineral aggregate, iron located on the surface of grains and surface area itself



# Stiffness of mastic is more important in Recycling than bitumen's penetration



Height after 25 minutes at 163 °C in RTFOT [mm]

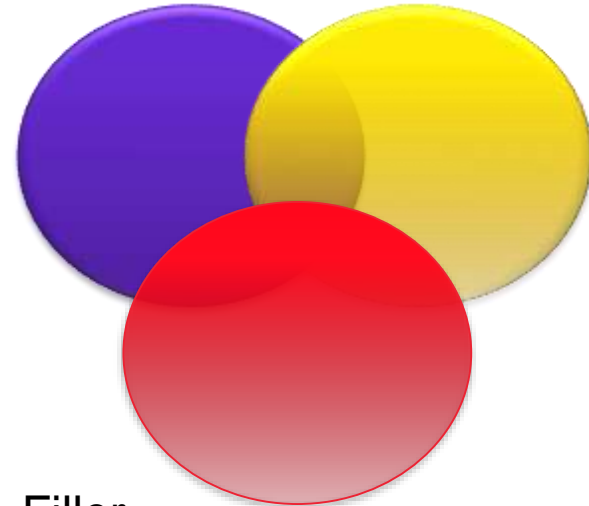


# Filler has mutual solubility with bitumen



Bitumen 1

Bitumen 2



Filler

Recovered organic component of fly ash



# Outline

- 1. Ring Road II phase 1 – conclusion
- 2. Ring Road II phase 2 – what have we learnt
- 3. Background for REM studies in Finland
- 4. My project goals and plan (outline)
- 5. Work Package one – sampling and experiences of REM on VT1.

# Research on REM adequacy is from times when maximum of 2 cycles were conducted

Laboratory data suggests that:

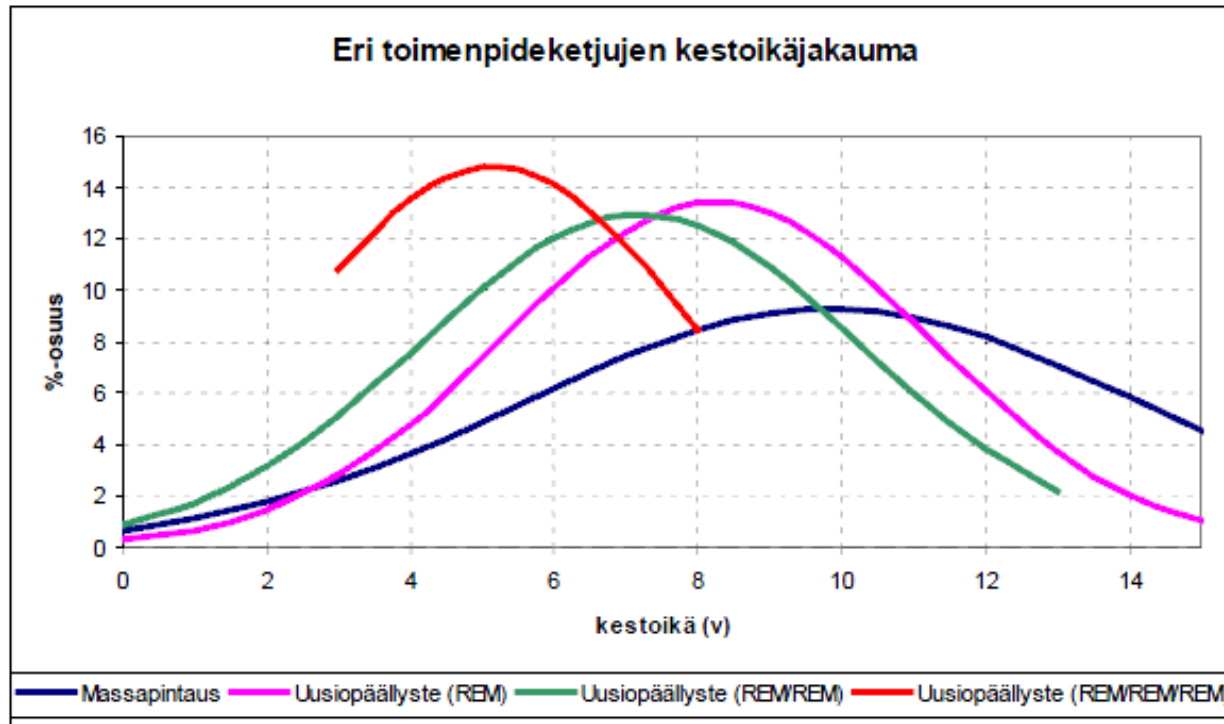
- the resistance to deformation and
- bitumen state after 3rd REM cycle

are of **too low quality**

No real 3rd time recycled road was analysed.

Uusiopäällystetutkimukset 1998, Laura Apilo, Katri Eskola, Tielaitoksen selvityksiä 7/1999

# After third REM cycle time to failure is 50% of fresh layer (also ca. 50% price)



# REMIX rules in Finland

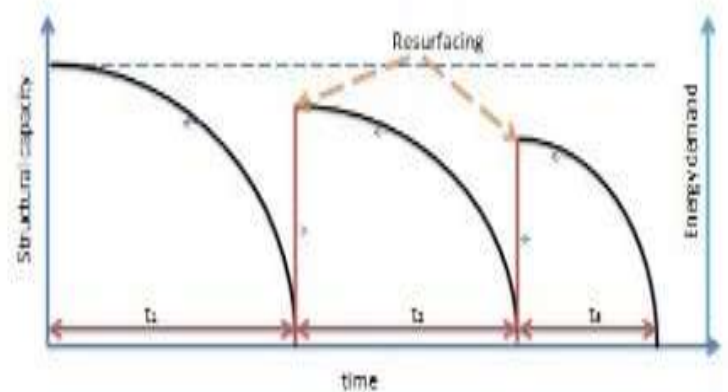
- Initial tests 4-5 cores in homogenic area
- Fresh admixture
  - 18 kg/m<sup>2</sup> (15-25 kg/m<sup>2</sup>)
- Bitumen 600/900 as rejuvenator,
  - 150-250 g/m<sup>2</sup>
- Allowed number of REMIX for wearing course → 2



Penetration decreases  
Air voids increase

<u>LTA</u>
<u>REM</u>
<u>REM</u>
<u>LTA</u>

4th cycle of life  
3rd cycle of life  
2nd cycle of life  
1st cycle of life



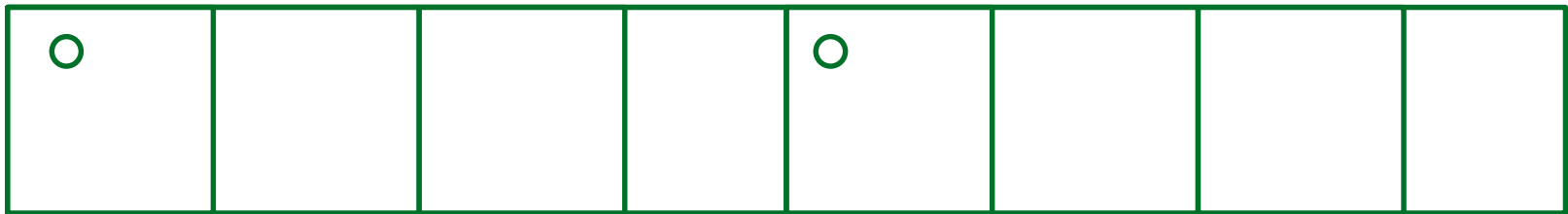
# Goals of the project

- Can knowledge of the road's history (construction records, raw material QC, maintenance records) improve success rates?
- Compare gain with REM over each cycle.
- Improve tender preparation (decision making)
- Provide tools for evaluation of pavement before REM
- How should we conduct post construction QC?
- What should be in the specifications?

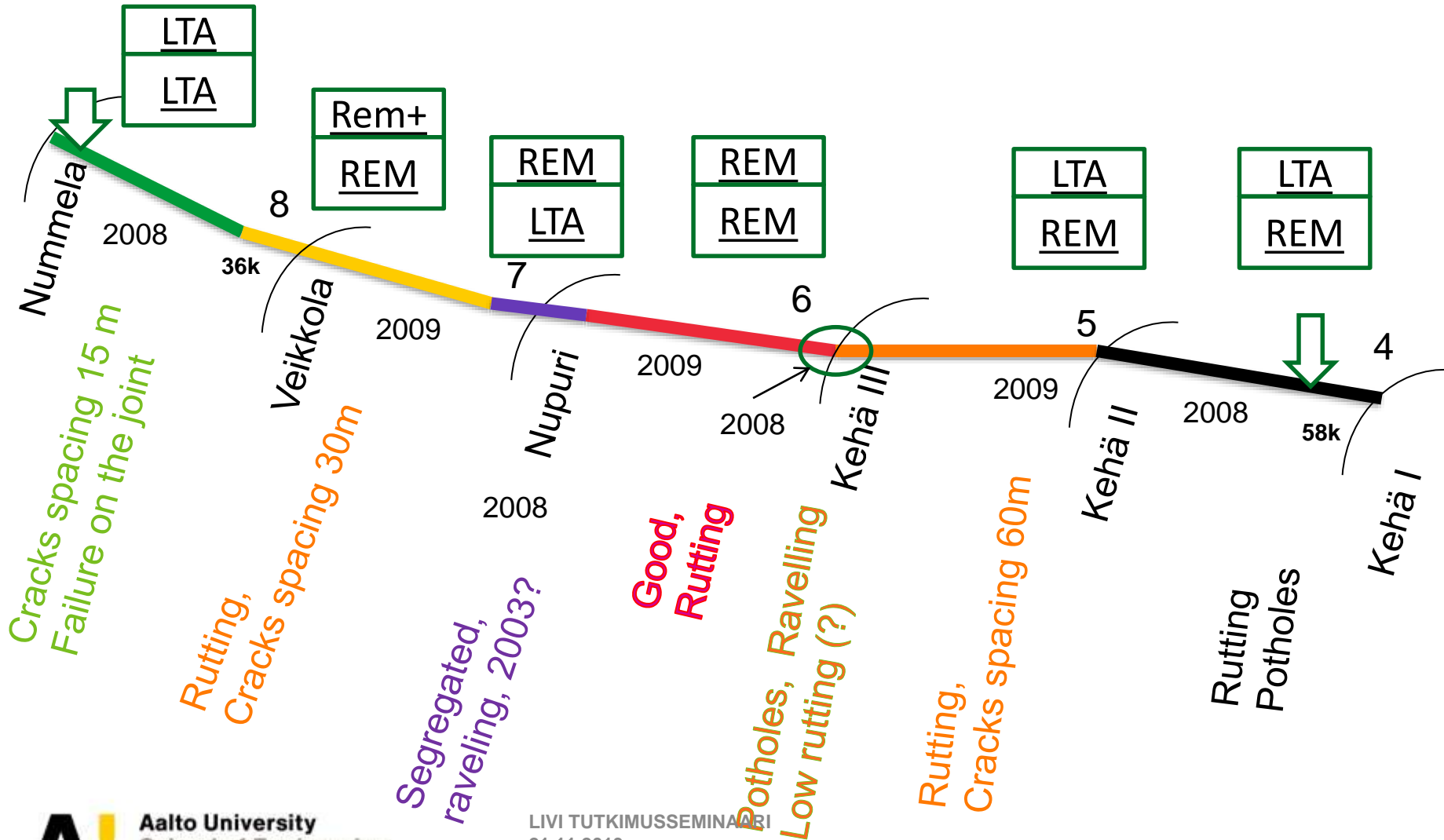


# Paving site definition

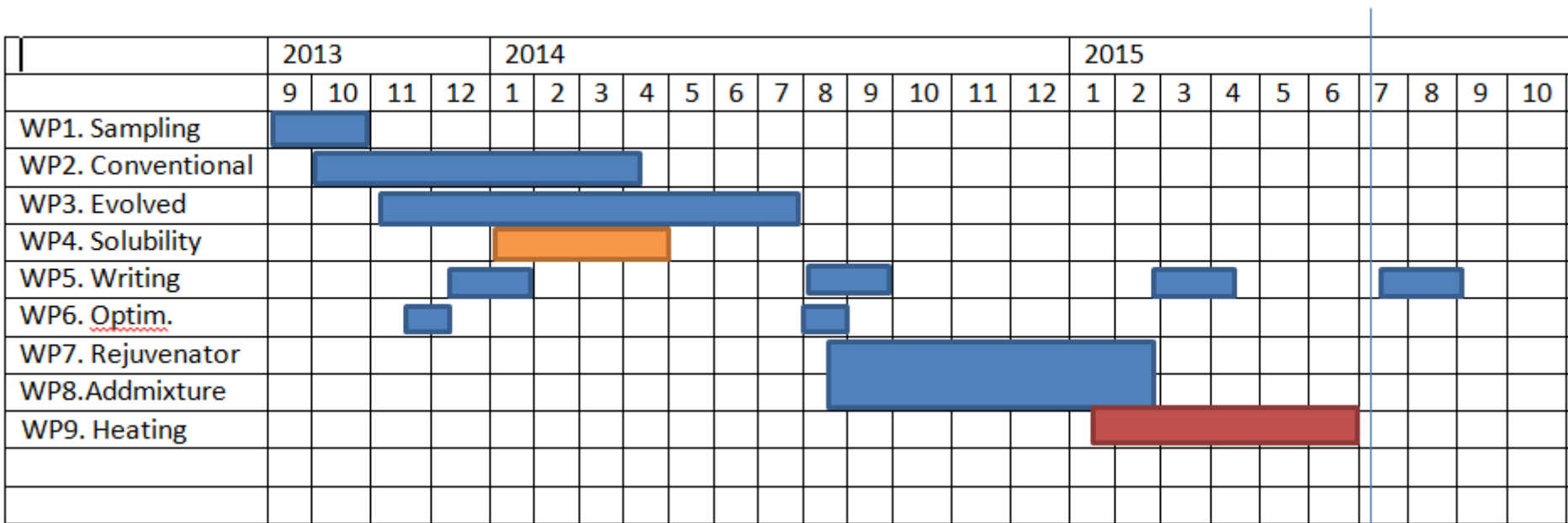
- "The number of sample sets depends on the size of paving site. A single paving site is regarded as being a paving entity of **one asphalt grade** that is made using **the same materials, the same asphalt plant, the same design values, the same mass per unit area ( $\pm 10\%$ )** and in **the same paving season.**" FAS 2000



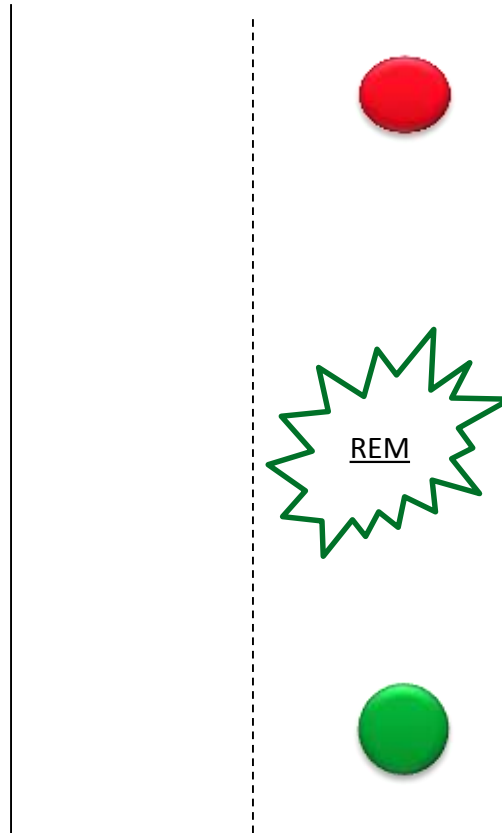
# VT1 – assesment (SMA)



# Project plan



# Experimental plan (destructive tests) – sample collection

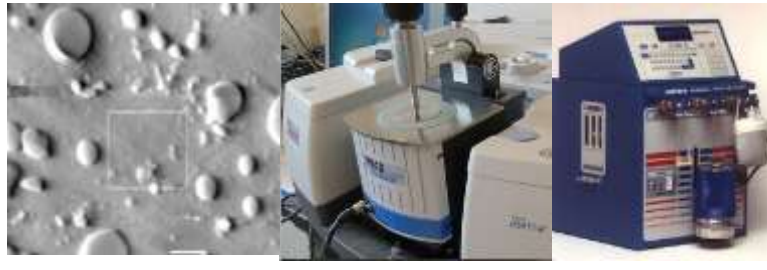
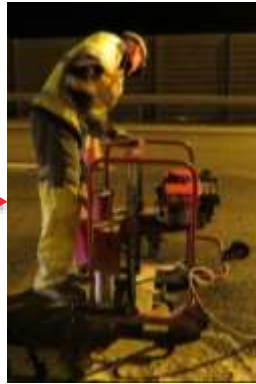


1. Core before REM

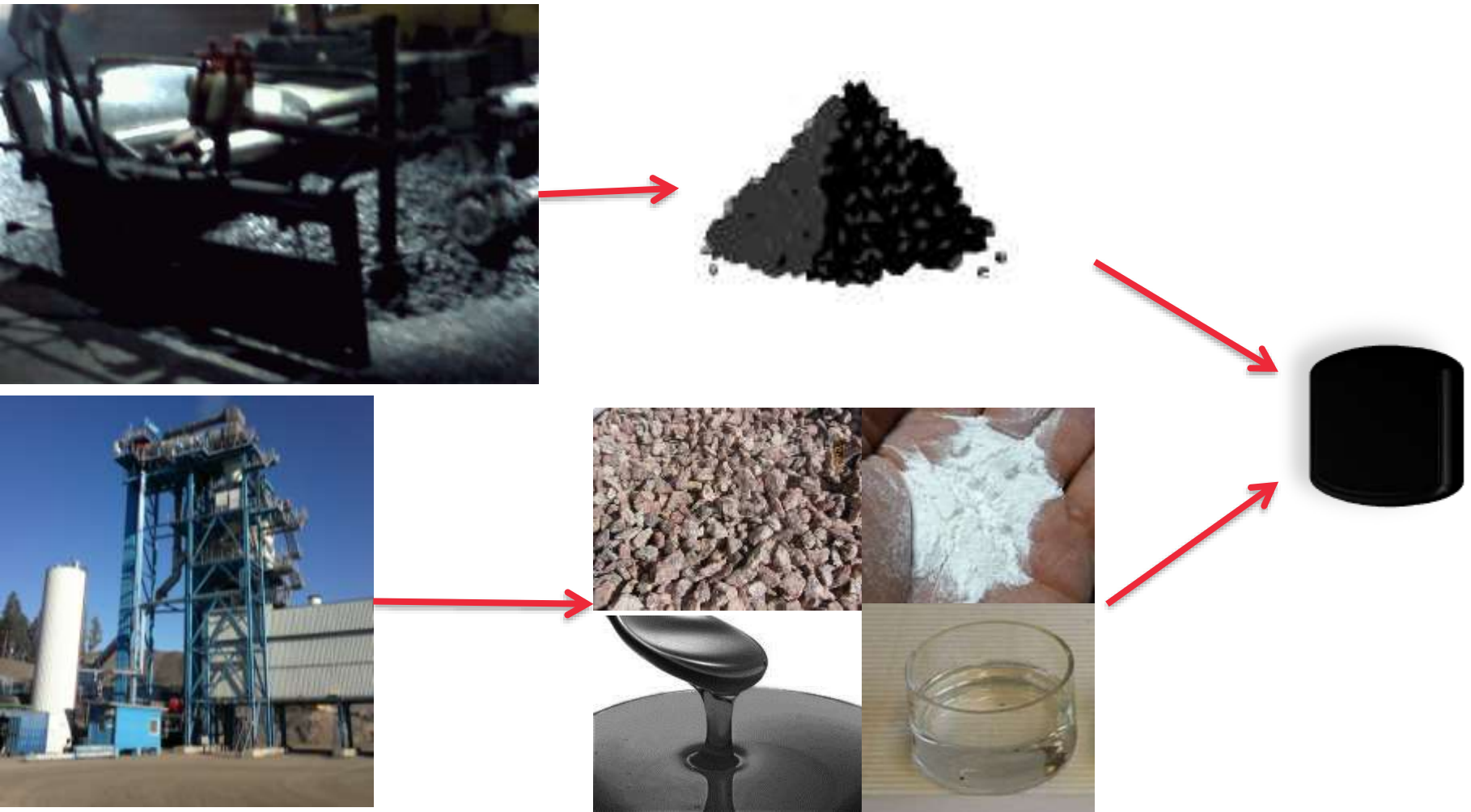
2. Milled material during

3. Core after REM

# WP1, WP2 and WP3 (Core Analysis)



# WP7 and WP8 (Rejuvenation, Addmixture)



# Knowing material shortcomings we could compensate with use of different admixtures

We will test effect of admixtures on:

- Compactibility
- Compatibility of materials
- Resistance to low temperatures,
- Deformation – comparison between the cycle stages and between different materials
- Aging

# Experimental plan (destructive tests) – planned basic tests



	Core before REM	Core after REM	Milled material
Thickness	WP2	WP2	-
Air Voids	WP2	WP2	WP7-8
Strength/Stiffness	WP2	WP2	WP7-8
Gradation	WP2	WP2	WP7-8
Bitumen content	WP2	WP2	WP7-8
Prall	-	WP2	WP7-8



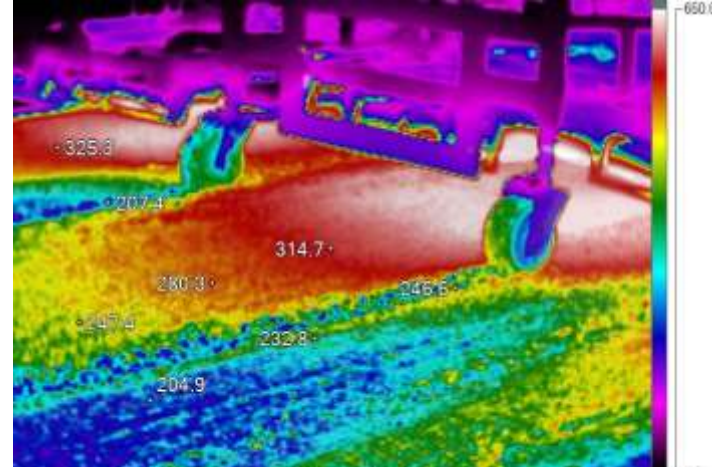
# Experimental plan (destructive tests) – planned evolved tests



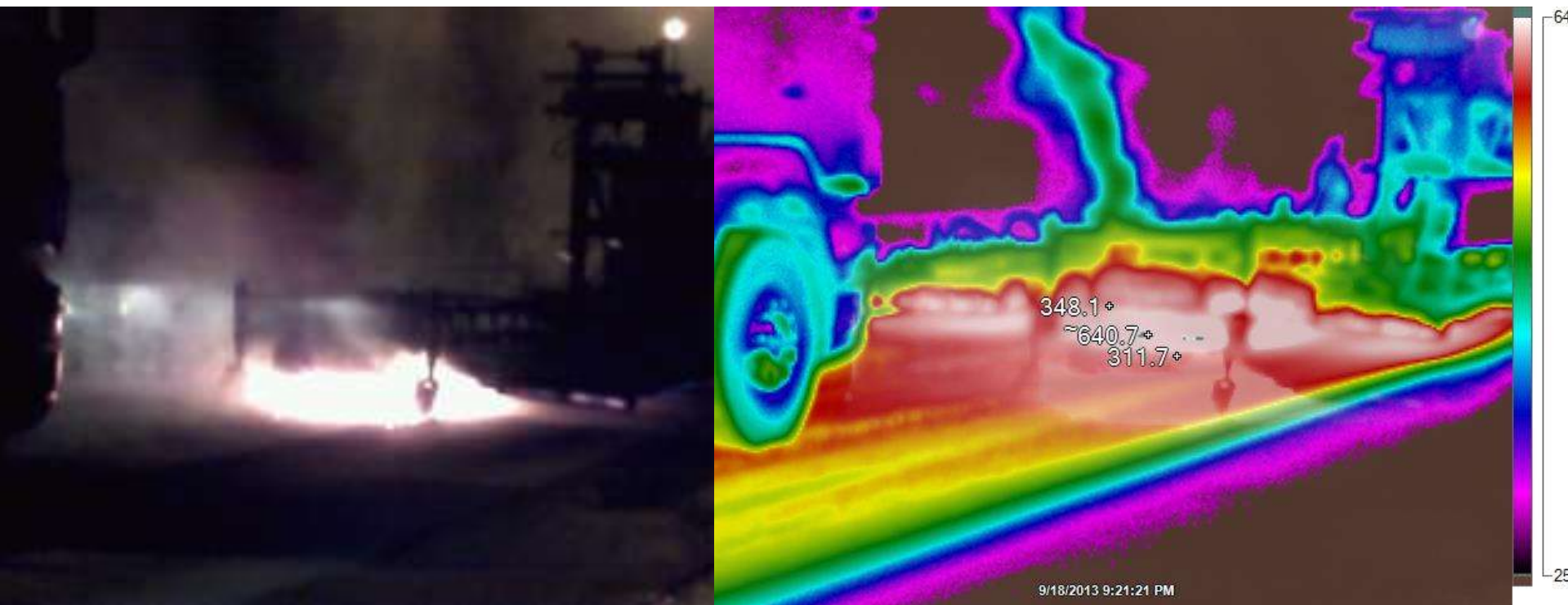
	Core before REM	Core after REM	Milled material
DSR, Pen, Fraass,	WP3	WP3	WP7-8
SARA	WP3	WP3	WP7-8
FT-IR	WP3	WP3	WP7-8
SA	WP3	WP3	WP7-8
FETCH	WP3	WP3	WP7-8

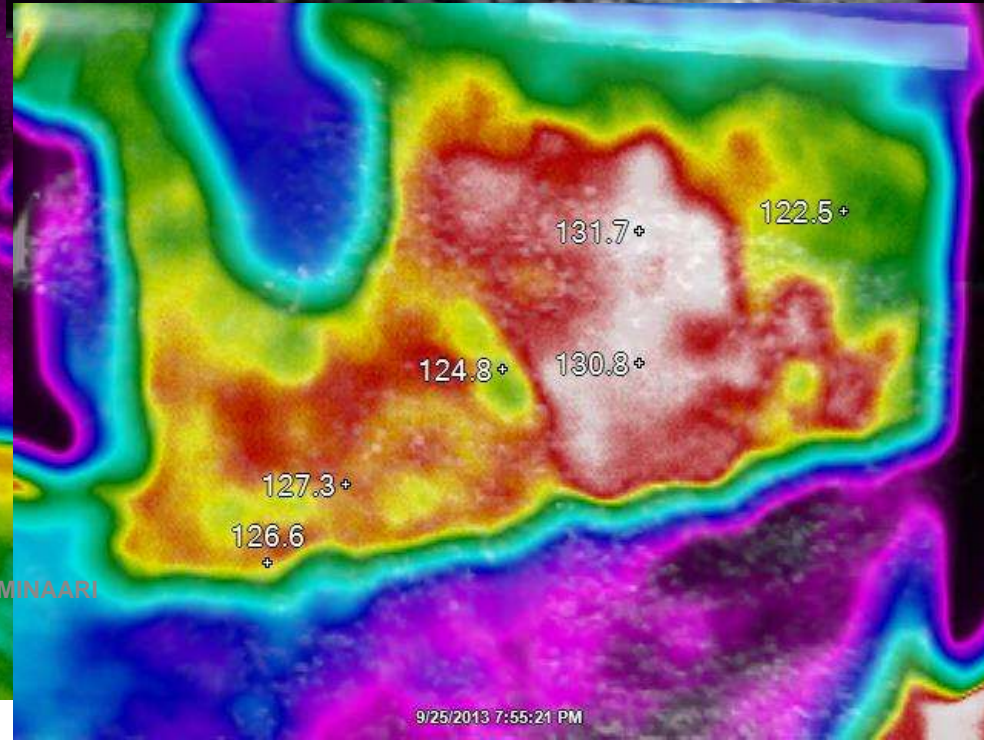
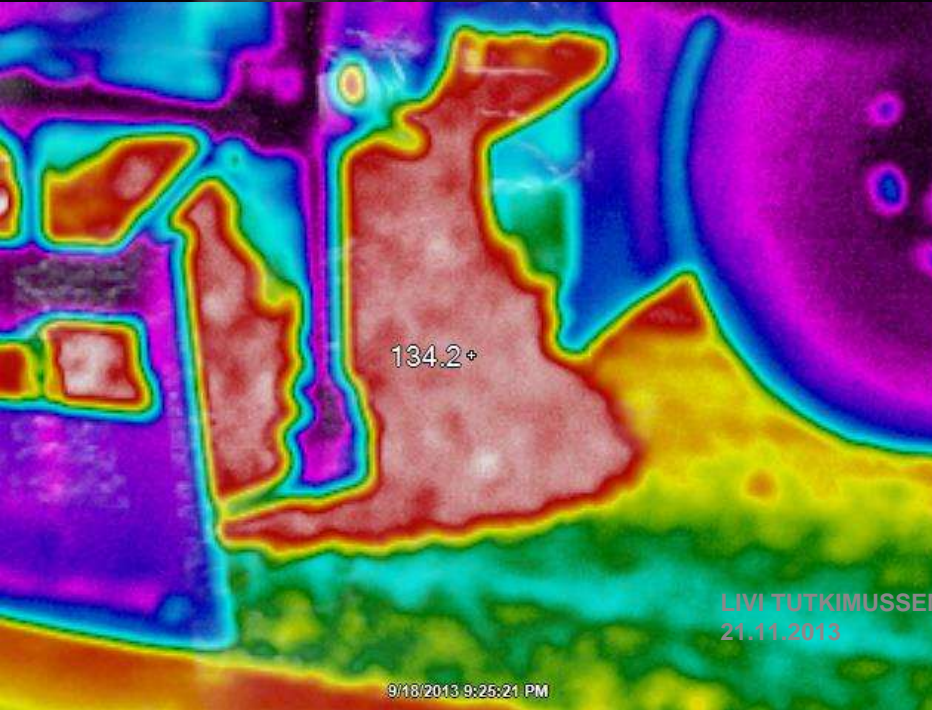
# Sampling consisted of non-destructive tests included:

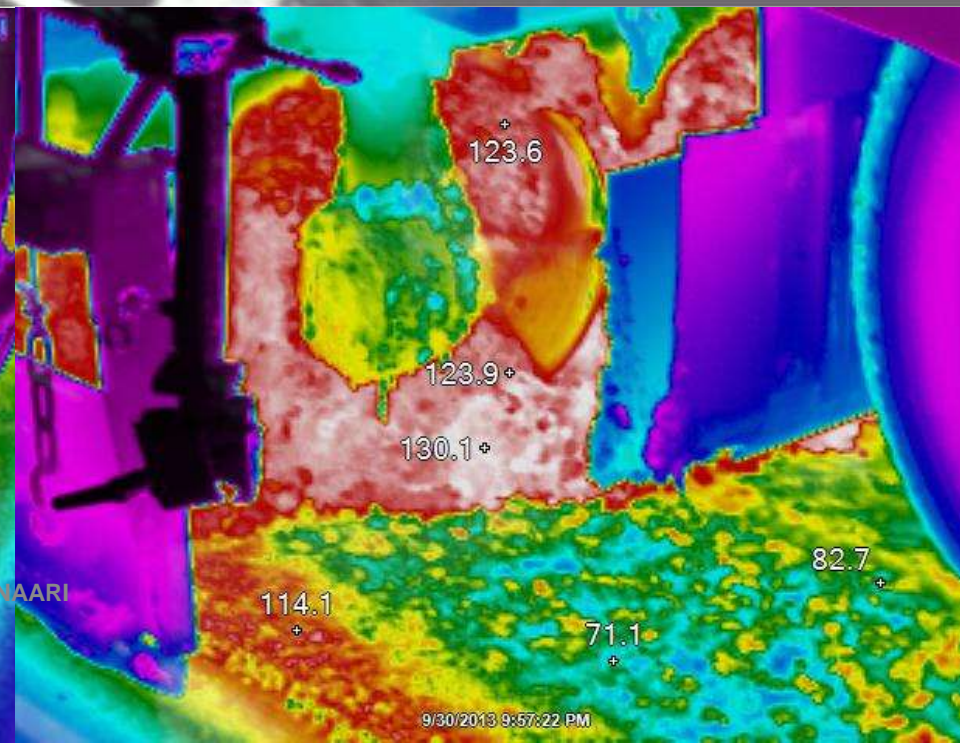
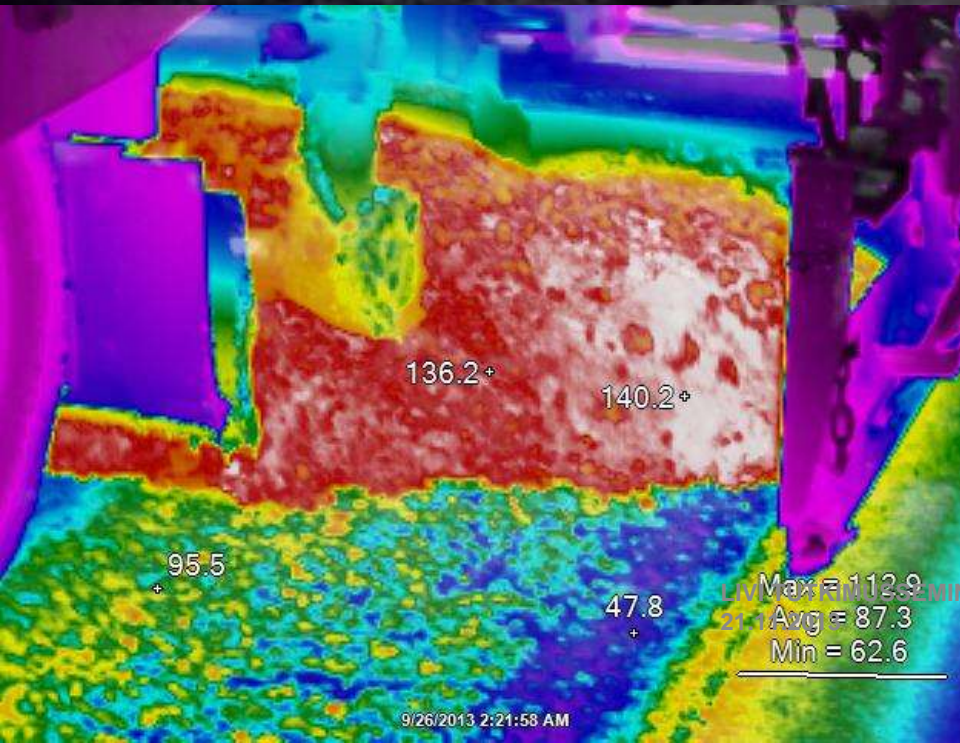
- visual inspection,
- Falling Weight Deflectometer
- rut depth + IRI,
- Ground Penetrating Radar,
- thermal camera (standard, before compaction)
- thermal camera at every REM stage



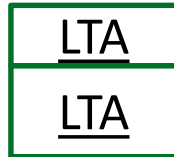
# Thermal camera observations



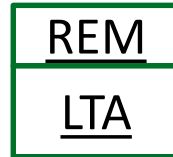




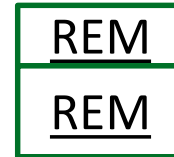
# Cores



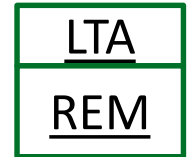
Cycle 1



Cycle 2



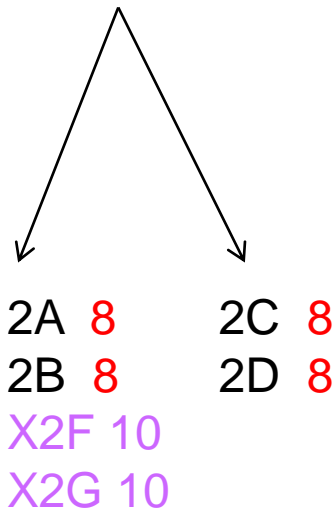
Cycle 3



Cycle 4



1A	11
1B	9
1E (crack)	1
X1F	10
X1G	10



3A	8
3B	8
X3F	10
X3G	10

4A	8
4B	8
X4F	10
X4G	10

Core total before REM works **85**

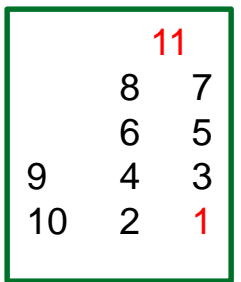
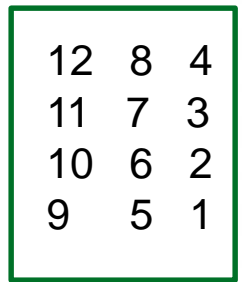
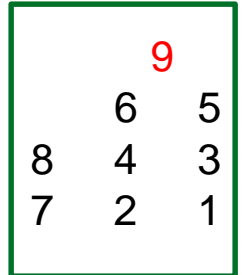
Core total after REM works **80**

LTA  
LTA



# Before

Veikkola

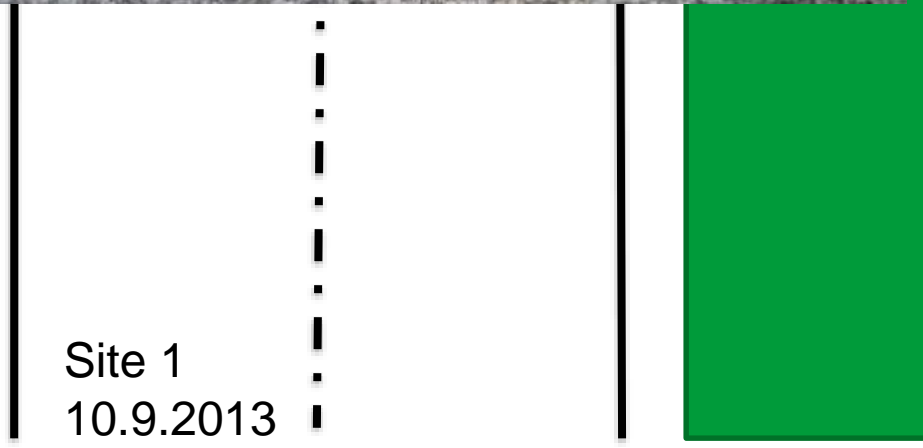


1B  
1/8/2400

1FWD  
1/8/2450

1E (12)

1A  
1/8/2500



Site 1  
10.9.2013

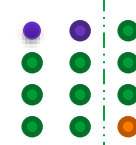


# After

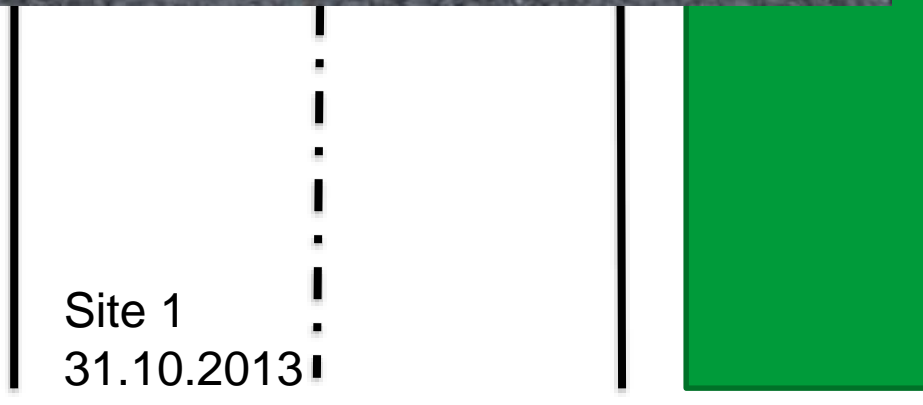
Veikkola

X1F=1FWD  
1/8/2450

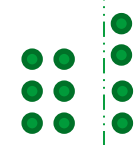
12	8	4
11	7	3
10	6	2
9	5	1



		10
6	5	9
4	3	8
2	1	7



		10
6	5	9
4	3	8
2	1	7



1G  
1/8/2340



# Before



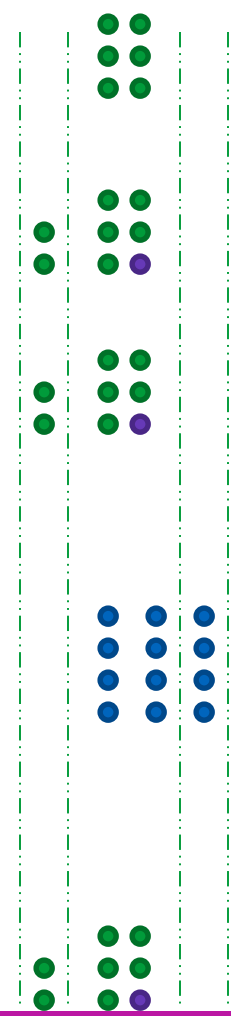
# After



# Before

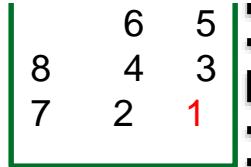


I III



- 2C  
1/6/4280
- 2B  
1/6/4300
- 2D  
1/6/4316
- 2FWD  
1/6/4350
- 2A  
1/6/4400

Site 2  
10.9.2013



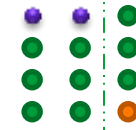
# After

Kehä III



Site 2  
31.10.2013

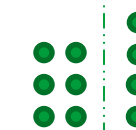
12	8	4
11	7	3
10	6	2
9	5	1



X2F=  
2FWD  
1/6/4350

		10
6	5	9
4	3	8
2	1	7

		10
6	5	9
4	3	8
2	1	7



X2G  
1/6/4400

# Before



# After



REM

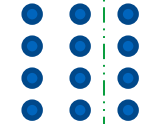
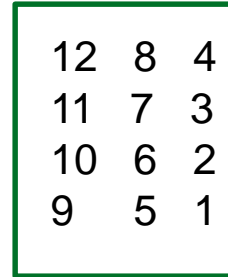
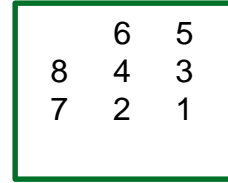
REM

# Before

Kehä III

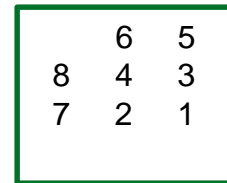
3B

1/6/2600



3FWD

1/6/2650

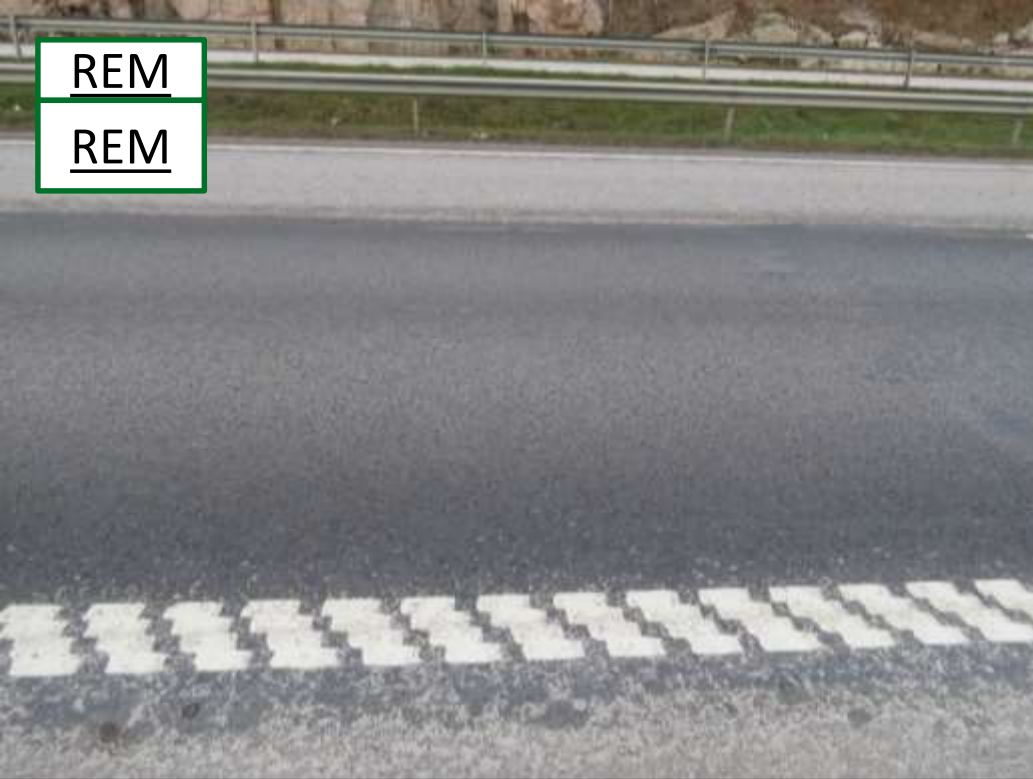


3A

1/6/2700

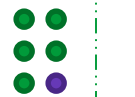
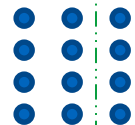
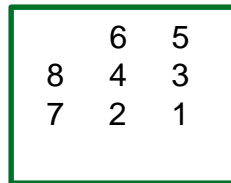
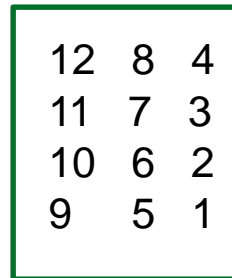
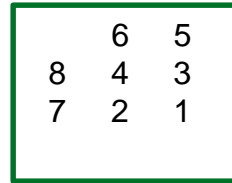
Site 3  
10.9.2013

REM  
REM



# After

Kehä III

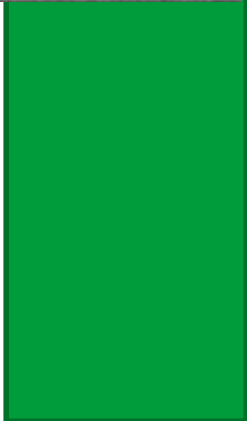


3B  
1/6/2600

3FWD  
1/6/2650

3A  
1/6/2700

Site 3  
31.10.2013



Nupuri

Yhdyskunta- ja ympäristötekniikan laitos

# Before



# After

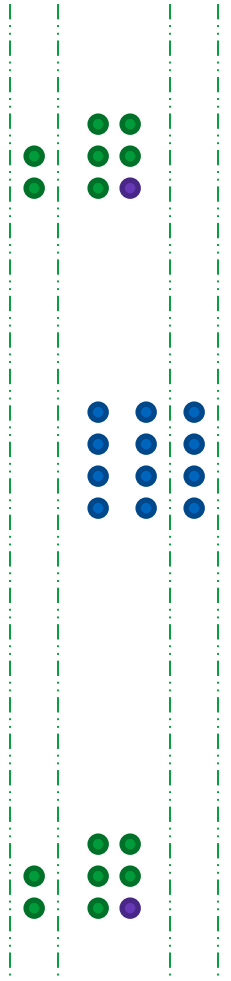
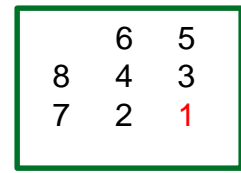
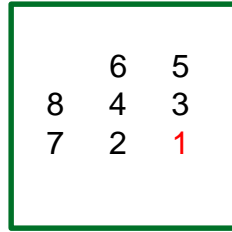


LTA  
REM



# Before

Kehä II

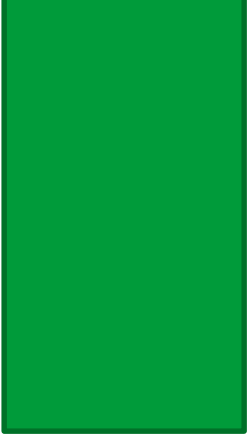


4B  
1/5/4300

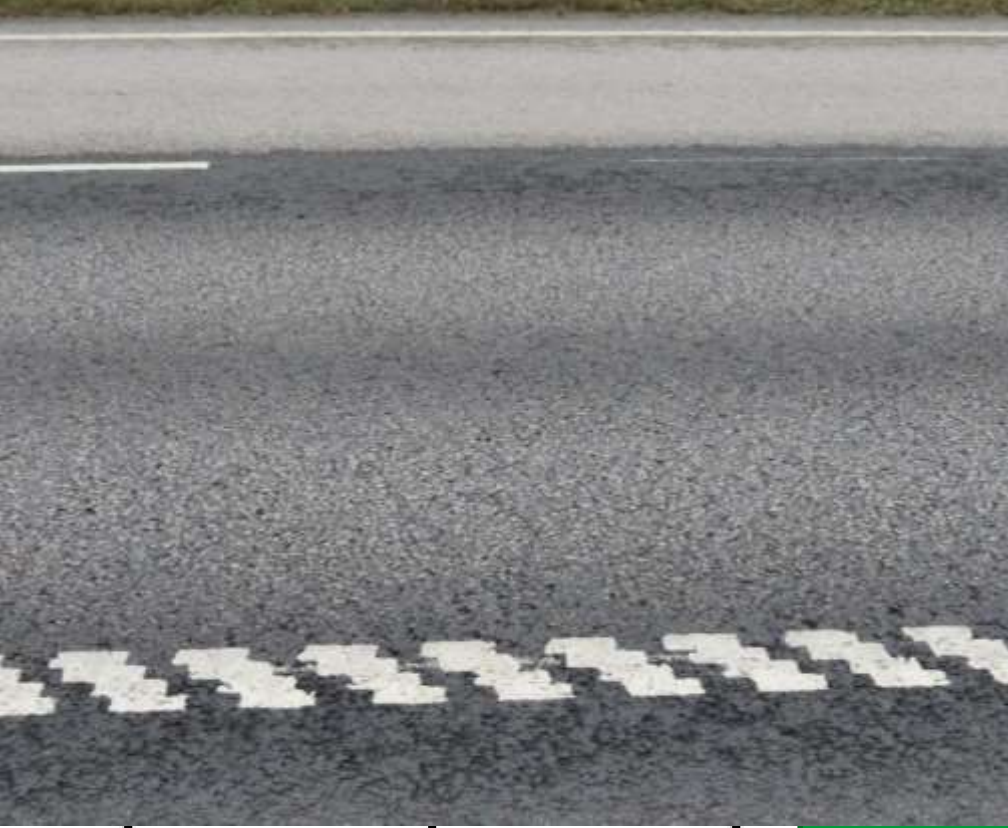
4FWD  
1/5/4350

4A  
1/5/4400

Site 4  
10.9.2013





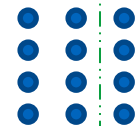
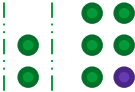
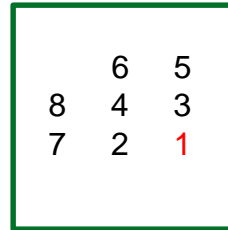


# After

Kehä II

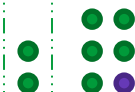
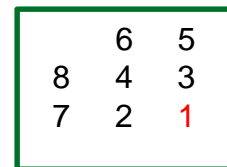
4B

1/5/4300



4FWD

1/5/4350



4A

1/5/4400

Site 4  
31.10.2013



# Before



# After



# Full cores before REM

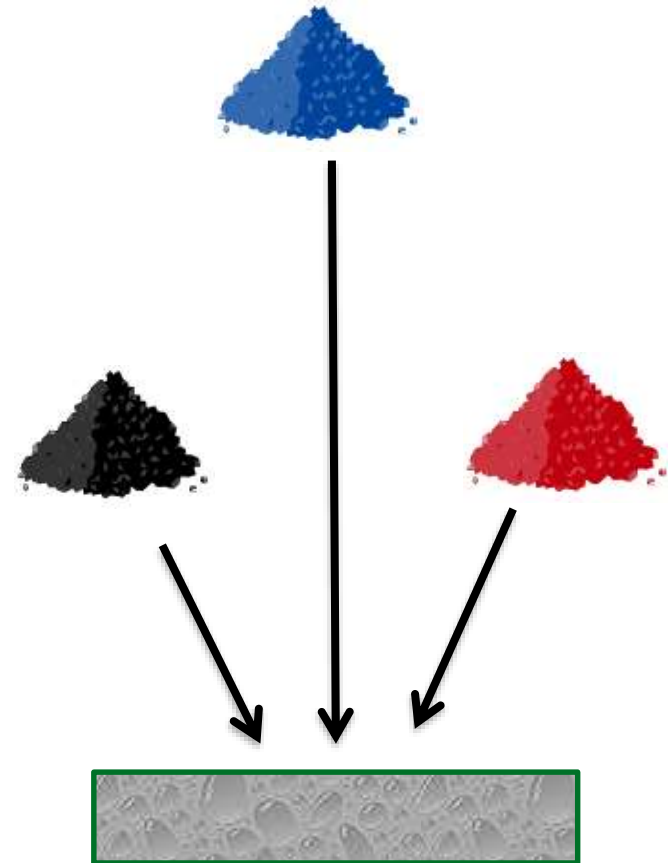


# Full cores after REM



# Summary

- Materials used for the construction, construction failures and materials added into the mixture during its lifetime will affect success rate in REM
- Project focuses on 3<sup>rd</sup> cycle of REM
- Project identifies and develops best practices for REM contract preparation



# Invitation for co-operation

- Are you willing to participate in the project?
  - Air Voids before and after
  - Gradation, bitumen content
  - Penetration values before and after
- Recovered binder and aggregate would be retrieved by Aalto staff.
- How do you choose your sampling sites?
- What is the depth to which you analyze the cores collected from the surface?

# Reading material

## **Tiepäällysteiden kestävyys ja rakenteellinen toiminta - Mitä voimme oppia Kehä II:n vauriotutkimuksen tuloksista?**

Pellinen, Terhi; Makowska, Michalina, Olmos Martinez, Pablo; Laukkanen, Olli-Ville; 2013; Tie & Liikenne, 7/2013; Suomen Tieyhdistys ry; Kerava; ISSN: 0355-7855

## **Durability of Ring-Road II asphalt pavement - Phase I report on forensic analysis of Ring-Road II pavement distresses**

Pellinen, Terhi; Makowska, Michalina; Olmos, Pablo; Laukkanen, Olli-Ville, 2013, Aalto University publication series SCIENCE + TECHNOLOGY, Unigrafia

<https://aaltodoc.aalto.fi/handle/123456789/10884> , Helsinki, ISBN: 978-952-60-5265-6, ISSN: 1799-4896, eISBN: 978-952-60-5265-, eISSN: 1799-490X

## **“Analytical methodology to determine the composition of filler used in HMA: Case study”,**

Makowska M., Pellinen T., Olmos P, Laukkanen O.-V., Proceedings of TRB 2014, paper no 14-1222

# Questions? Suggestions?

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