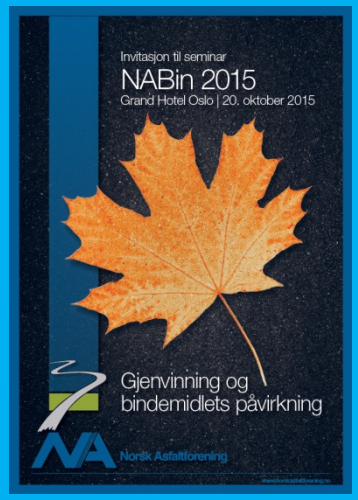
Recycling in high trafficked roads in Denmark

Experiences, challenges and specifications



Erik Nielsen, Vejdirektoratet (Danish Road Directorate)

at NABin seminar in Oslo, Norway 20th October 2015

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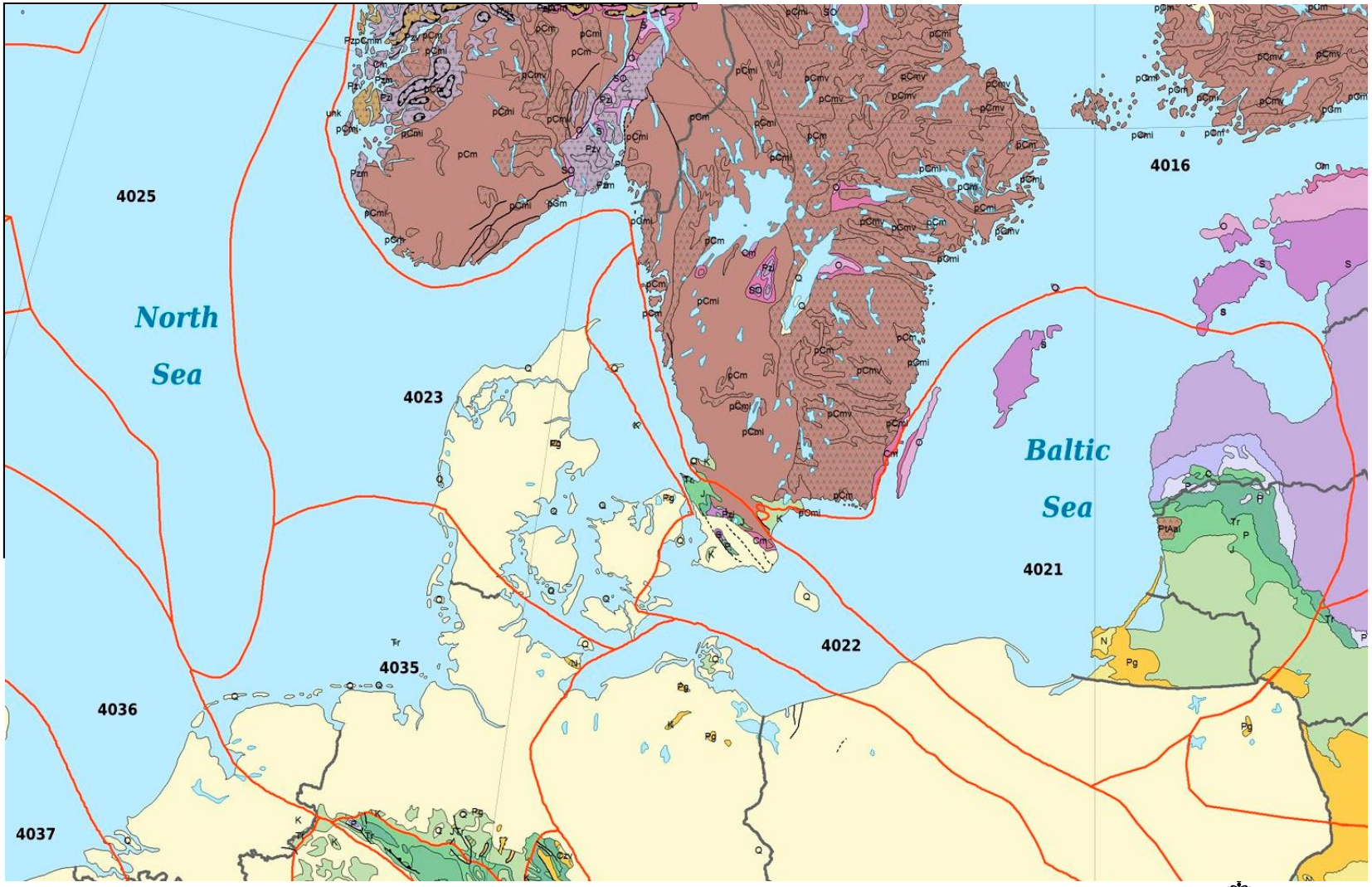
Outline

- A few words of background about Denmark
  - Geological history and impact on roads
  - Asphalt recycling
  - Market and asphalt plant configurations
- Recycled asphalt for high trafficked roads – International projects
  - Re-Road – EU 7th Framework Programme co-financed project
  - RECYPMA – ERANET Road financed project
- Present level of recycling allowed in Danish guidelines for asphalt
- Challenges for a Danish (national) road administration
- ”Circular Asphalt Production” – Environment co-financed project.

Denmark – geological background



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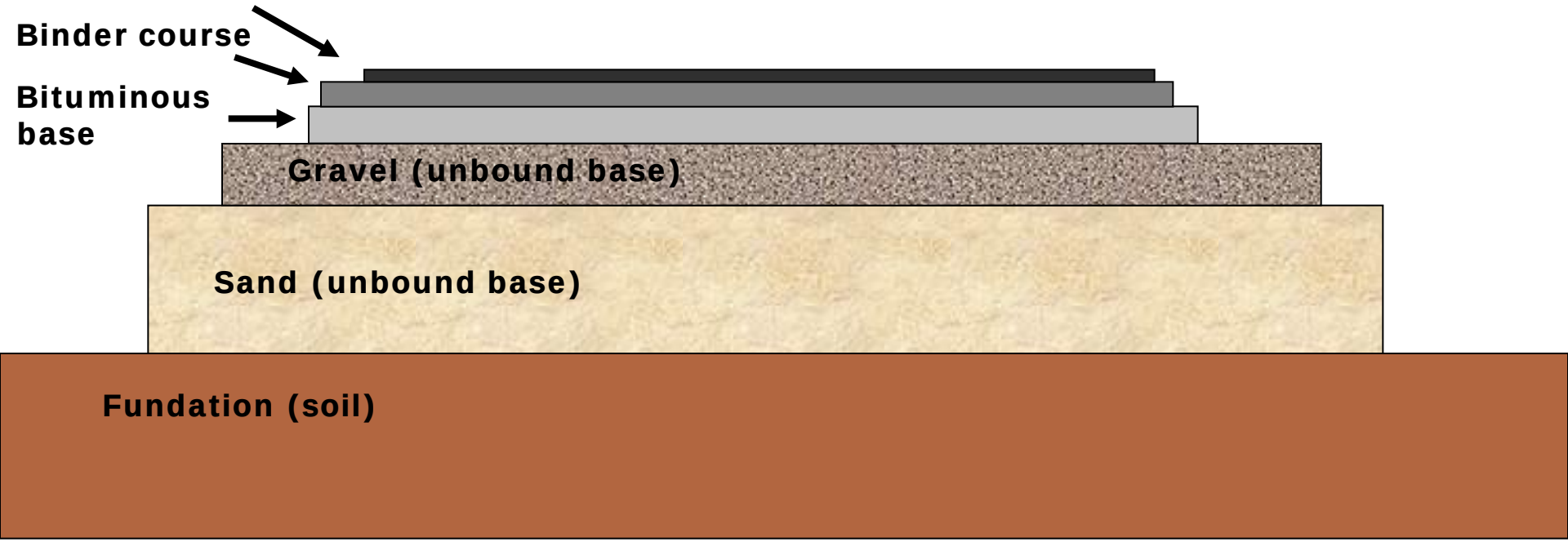
Geological impact on road building

In order to use local resources from glacial deposits

- aggregates with a minor content of frost-sensitive particles and
- uncrushed sand

have been allowed in bituminous bases and binder courses.

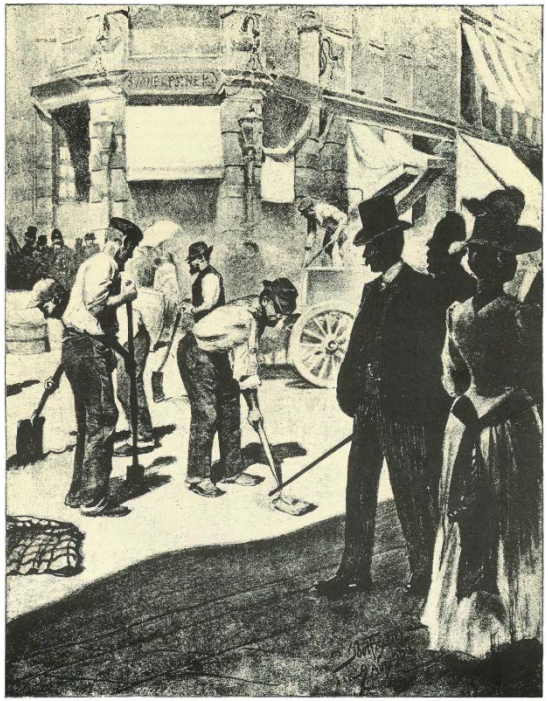
These materials are on the other hand not allowed in surface layers of high trafficked roads due to durability



Denmark – asphalt recycling background

- 1890 First asphalt job in Denmark – city street in Copenhagen - August 1890
  - It was recognised that Mastic Asphalt could be melted and reused (”recycled”)
- 1980 ”Modern age of recycling asphalt” starts
  - The energy crisis in the 1972 and 1979 turn focus for Denmark on recycling asphalt (potential for both aggregate and bitumen)
  - Joint study tour for asphalt contractors, road administrations and consultants to USA to assess the situation ”over there”
  - After the study tour the national road standards committee on asphalt pavements concluded:

    ”As long as the present asphalt specifications are met, there is no reason to hinder recycling of asphalt”



Asfalteringen af Østergade i København, august 1890. Tegnet af Poul Fischer.

Denmark – market and asphalt plant configurations

- 1980 and forward
  - Denmark had (and still has) predominantly batch plants as the market situation typically consists of many and smaller (relative) jobs
  - In the early years ”cold feed” conveyor belts were added to the batch plants
  - Later when small asphalt plants were replaced with larger ones, the old virgin drum dryer was often used as “parallel drum” for recycled asphalt
  - In the last decade there has been a trend towards skipping the parallel drum and in stead use different techniques in combination with the virgin drum dryer to introduce the reclaimed asphalt.

Recycling percentage in hot mix (with approx. max. limits):

“cold feed” → 17-25 %

“virgin drum + something” → 40-45 %

“parallel drum” → 55-65 %

Figures depend a lot on the technology, type and water content of RA.

Denmark – asphalt and recycling in figures

2014

- Denmark produced 3,700,000 tons hot mix asphalt.
- This included 700,000 tons of reclaimed asphalt.
- On the total production the recycling percentage has been approx. 19 %.
- This is almost the same as in 2013, but the increase in recycling percentage in former years seems to level off.

2015

- The similar figures for production and reclaimed asphalt are estimated to be on the same level (or perhaps a little less)

Recycling in high trafficked roads – international projects

- From 1980 and forward the Danish experience in recycling has been gained in production of bituminous base course materials.
- The main reason has been a (“vicious”) cycle of
    - A lot of new construction (development of primary road network, new motorways, strengthening of existing highways, thick bituminous bases)
    - Limitations in storage capacity of reclaimed asphalt in the “environmental permissions” given to the asphalt plants and material depos
    - All reclaimed asphalt from utility works and milled old pavements went into one stock pile which from time to time was processed into one product (perhaps in two fractions 0/11 mm and 0/22 mm)
- With increased focus on sustainability in this millennium and to gain knowledge Vejdirektoratet participated in two international projects with focus on high content recycling in surface layers for high trafficked roads

Re-Road and RECYPMA

Re-Road

- **”Re-Road – End of Life strategies of asphalt pavements”**
- **EU 7th Framework Programme Budget 3.2 mil. €**
- **Theme: Energy, Environment & Resources**
- Project period: January 2009 – December 2012
- Consortium:
  - VTI, Sweden (project coordinator) – in total 18 partners including
  - Vejdirektoratet (Danish Road Directorate) which contributed with 6.8 %
- Web-address: *http://re-road.fehrl.org/*

Practical interpretation of the objective of Re-Road:
- To achieve ≥ 40 % of reclaimed asphalt without downgrading in surface layers for high trafficked roads in Europe.

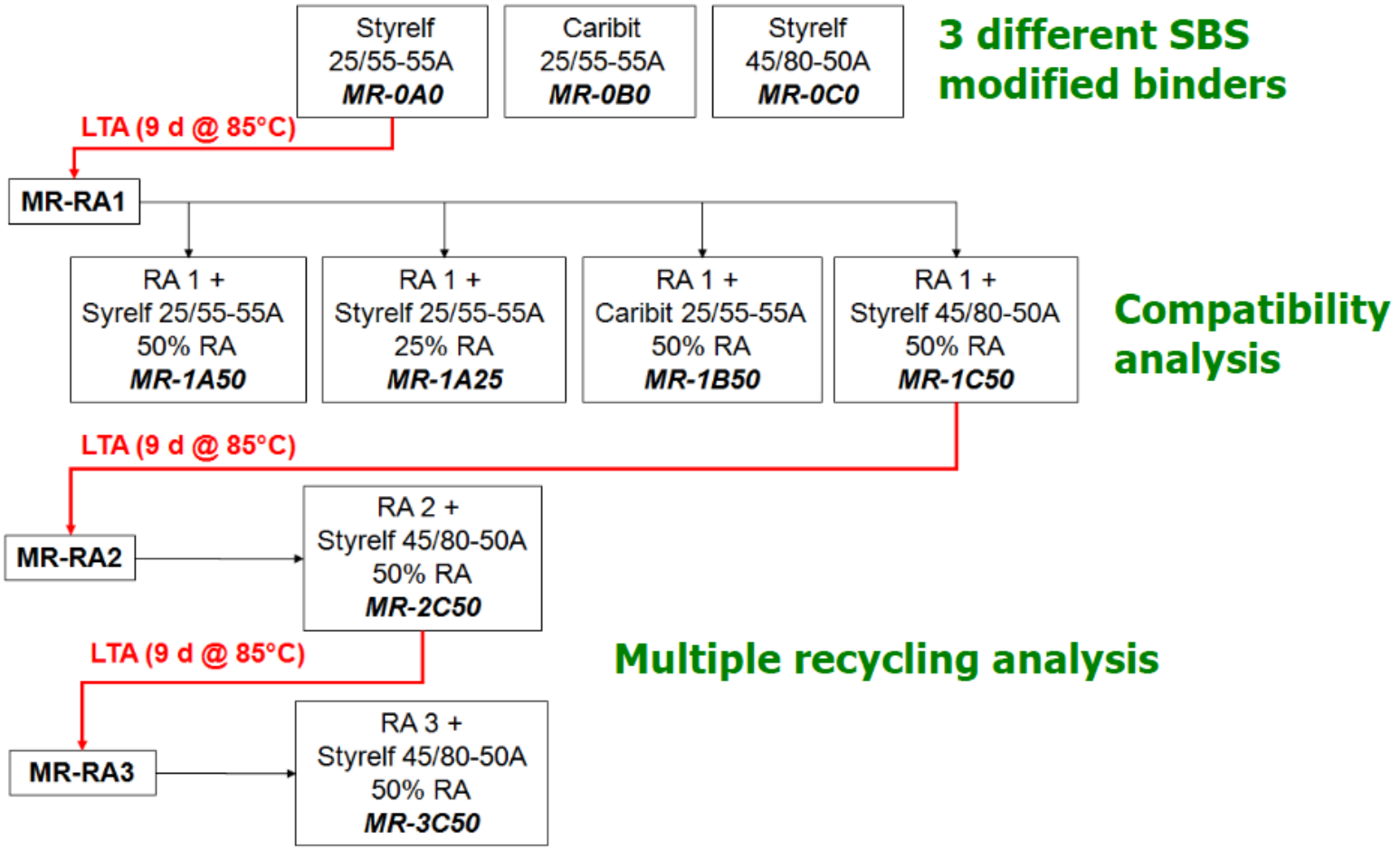
Re-Road – multiple recycling study (1)

Work Package 2 "mix design and performance of asphalt containing RA" had several subprojects, but one of them was a multiple recycling study.

The study had the following elements:

- The control mix : SMA 8 with modified bitumen 25/55-55A
- Simulated Long Term Ageing (LTA) was performed with a RILEM procedure (loose mix stored at 85 °C for 9 days)
- 3 recycling cycles were used.
- At each recycling event the new asphalt contained 50 % RA
- The virgin bitumen at each recycling was 45/80-50 A

Re-Road – multiple recycling study (2)



Re-Road – multiple recycling study (3)

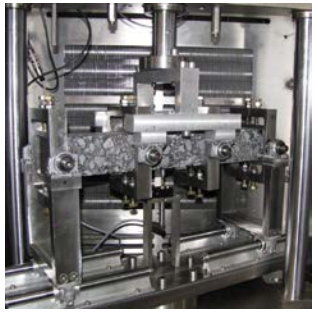
Conclusion:

All relevant mechanical properties for the mixes containing 50 % reclaimed asphalt are in the range of the fresh mixes with 25/55-55 A (2 different polymers)

- Compactibility (impact compaction)
- Resistance against rutting (Cyclic triaxial stress test)
- Stiffness (4-Point-Bending)
- Low-temperature cracking

(Thermal Stress Restrained Specimen Test +

Uniaxial Tension Stress Test)



RECYPMA

- ”Possibilities for high quality RECYcling of Polymer Modified Asphalt”
- **ERANET Road** - financed laboratory research project under
- **Call 2011: ENR – Design** ("Rapid and durable maintenance Methods and Techniques”)
- Project period: October 2011 – September 2013
- Consortium:
  - TNO – The Netherlands (project coordinator)
  - Delft University of Technology – The Netherlands
  - University of Zilina – Slovakia
  - Vejdirektoratet (Danish Road Directorate)
- Web-address:
  http://www.eranetroad.org/index.php?option=com_content&view=article&id=110:2011-design&catid=31:standard&Itemid=46#RECYPMA

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RECYPMA

The objective of the project:

- To ensure that reclaimed asphalt containing polymer modified bitumen will be recycled at its highest practical potential.
- To avoid down-grading of reclaimed asphalt containing a potential valuable assset.
- To anser questions like:
  - What is the potential of using reclaimed polymer modified asphalt in new asphalt?
  - What is the benefit?
  - Which steps should be taken to technically implement this recycling process?

RECYPMA

The three countries in the project provided each a reclaimed asphalt containing polymer (SBS) representing three different asphalt families which had been used for high trafficked roads.

The Netherlands:	7 years old porous asphalt (PA 8) containing 40/100-65
Slovakia:	15 years old dense graded asphalt concrete (AC 11) containing 50/100-70
Denmark:	22 years old stone mastic asphalt (SMA 11) containing 70/100-75

The bituminous binder were extracted to be characterized and used in binder–blending studies and the reclaimed asphalts were used for new asphalts of similar types.

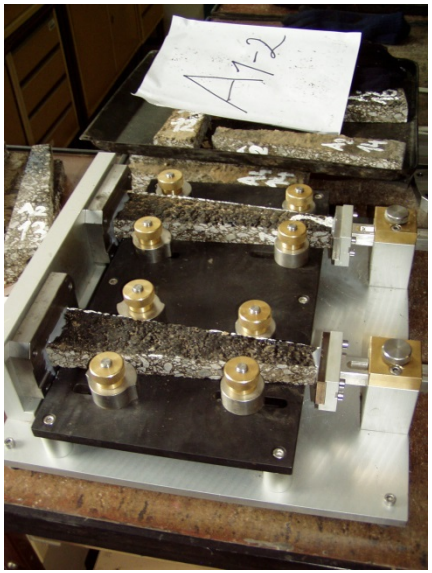
Following virgin binder types were used:

Paving grade bitumen 70/100 and

Either PMB 70/100-83 or PMB 90/150-75

RECYPMA

- Recycle percentages of 0, 15 and 40 % were chosen to respond to practical asphalt plant configurations.



RA content of	SMA 11		PA 8		AC 11	
	PGB	PMB	PGB	PMB	PGB	PMB
0 %	x	x	x	x	x	x
15 %	–	x	–	x	–	x
40 %	x	x	x	x	x	x

- Using 15 % RA with a virgin paving grade 70/100 would result in down-grading the potential of the reclaimed asphalt containing polymer modified binder and the combination was not examined.
- Blends of binder were tested for Penetration Softeningpoint R&B, viscosity at several temperatures, master curves by DSR, FTIR spectra and molecular weight distribution by GPC.
- Mechanical tests were performed on asphalts (water sensitivity test, wheel tracking test, stiffness and fatigue test) according to national requirements.

RECYPMA

Conclusions:

- The rheological properties of three recovered binders were quite different
- Depending on the polymer “characteristics” of the recovered binder it can either easily by influenced by the new added polymer modified bitumen or be rejuvenated by adding a soft grade of binder.

$$\log Pen_{mix} = a \log Pen_1 + b \log Pen_2$$

$$T_{S.P.mix} = a \times T_{S.P.1} + b \times T_{S.P.2}$$

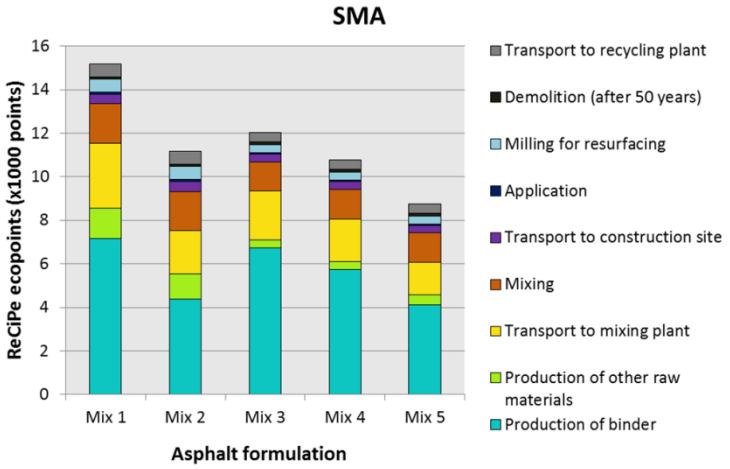
$$a + b = 1$$

- Mixing laws – based on either Log Pen or Softening Point R&B – can be useful in prediction, but mixing laws with Softening Point R&B can be biased if value higher than or close to 80 °C occurs (water/glycerine).

RECYPMA

Conclusions (continued):

- Content of SBS by FTIR can be estimated in blends, but only using paving grade bitumen. The content of SBS can not give the level of breakdown of the polymer.
- Material properties of the bituminous mixes showed the positive benefits of the polymer in the reclaimed asphalts; also when 40 % RA was used together with virgin paving grade bitumen.
- Life Cycle Analysis and Life Cycle Costs were performed on scenarios with data and assumptions from the study. The use of 40 % RPMA reduces the LCC of the new asphalt with approx. 10-18 %.



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Present level of recycling allowed in Danish guidelines for asphalt - 2015

Reclaimed Asphalt (RA) can be utilized as stated below under the condition, that material specifications for bitumen, aggregates and filler are met:

- Reclaimed asphalt can be used in all bituminous base courses.
- In dense graded surface layers reclaimed asphalt can be added up till 30 % .
- In open graded surface layers and in Stone Mastic Asphalt reclaimed asphalt can be added up till 15 % .
- In binder courses for low trafficked roads ($Æ_{10} \leq 500$) reclaimed asphalt can be added up till 30 % .
- In binder courses for high trafficked roads ($Æ_{10} > 500$) reclaimed asphalt is not allowed.

Vejdirektoratet has – more or less – declined the use of reclaimed asphalt in surface layers and in binder courses with $Æ_{10} > 500$.

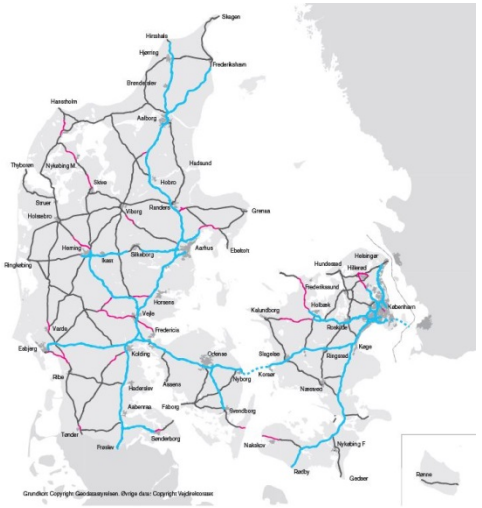
Challenges for a Danish (national) road administration (1)

Total length of public roads in Denmark

74,472 km

Of these is the national road network

3,796 km (or 5.1 %)

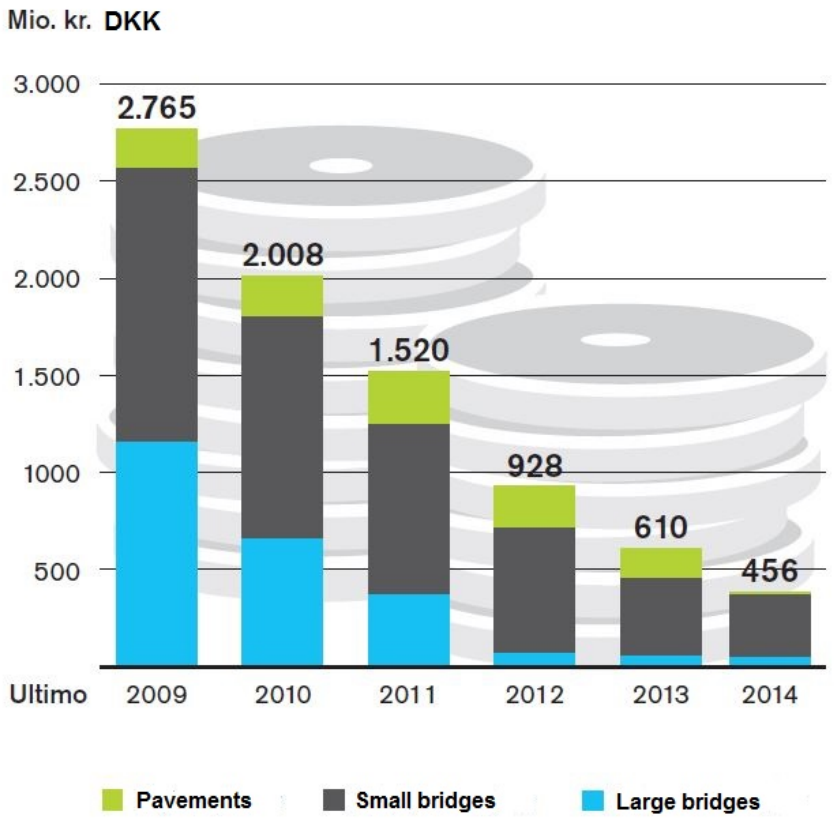


- But these 5.1 % of the roads in Denmark carries 46 % of the traffic work
- **Mobility of the road user has high (if not the highest) priority for the national road administration**

Challenges for a Danish (national) road administration (2)

- The backlog of funds for maintenance has shown a positive development over the last years, but we are not ”home free”, yet.

- Vejdirektoratet has been active in R&D for noise reducing pavements for more than a decade but there are still challenges with respect to expected durability and long term effect of the noise reduction.



- Vejdirektoratet has also put low rolling resistance pavements (**COOEE**) and carbon foot print on the agenda.

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Challenges for a Danish (national) road administration (3)

Sustainability is an issue for society as well as for the national road administration, and recycling of old asphalt surface layers into new surface layers is one piece in the puzzle.

But a lot of the focus over the last decade have been on thin surface layers

- with high functionality and
- small nominal maximum aggregate size

(e.g. noise reduction or low rolling resistance). It is almost impossible to introduce reclaimed asphalt in these mixes and still ensure control on the functionality.

Challenges for a Danish (national) road administration (4)

Recent years have given experience and disappointment

- with the material durability for maintenance operations on milled substrate and
- and varying or failing functionality of the noise reduction capability

with respect to expectations of low noise pavements.

Vejdirektoratet considers durability as a key parameter and is reluctant to compromise on quality on surface layers for high trafficked roads.

Challenge for recycling:

Aggregates for surface layers

Zero tolerance on quality ?

Circular Asphalt Production

- Joint research project
  - Lemminkäinen A/S
  - Asphalt Pavement Association
  - Local Government Denmark
  - Danish Technological Institute
  - Vejdirektoratet (Danish Road Directorate)
- June 2015 – June 2017
- Co-finansed by The Danish Environmental Protection Agency

Circular Asphalt Production

- The main objective of the project is to document conditions under which it is possible to recycle old asphalt surface layers into new surface layers – hopefully beyond a content of reclaimed asphalt of 15 %.
- Activities to achieve and document this goal are:
  - Development of a strategy for milling, sorting, crushing and storage of reclaimed asphalt
  - Identification of critical processes in production and paving
  - Environmental impact (primarily linked to leaching and storage)
  - Life Cycle Assessment/Life Cycle Cost of asphalt production
  - Mix design (evaluation of material properties)
  - ”Birth certificate” of trial section(s) to demonstrate achievements
- Target materials: SMA 11 and Binder course 16 for $Æ_{10} > 500$


Thank you
for your attention
Questions?
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