Pavements to reduce rolling resistance and vehicle CO₂ emissions

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International activities for low rolling resistance research

- Pavement condition and quality
- Measurement methods and data
- Influence Environment Socio economic
- Traffic safety Comfort Durability
- Models Effect Energy CO₂
- Implementation Construction and Maintenance
- MIRIAM – Pooled fund
- MIRAVEC – ERA-NET
- ROSANNE - EU
- COOEE – DNF
- InnoEnergi - DRD
- ROSE – DNF

International activities for low rolling resistance research
Effect, Potential and Challenges

CO₂ reduction for a competitive price
Socioeconomic calculations shows that the price for obtaining the CO₂ reduction is competitive in relation to other CO₂ reducing actions.

Other focus point are safety and noise
We do not want to jeopardize safety and noise, so skid resistance and tyre/road noise has been measured. These measurements have shown that the low rolling resistance pavements has a good skid resistance and a noise reducing effect.

Durability – 2017 will provide a well defined asphalt type to be commercially constructed in 2018.
In 2016 durability of 14 different asphalt mixes, based on SMA 6 and SMA 8 has been tested. The test results shows that the low rolling resistance SMA 8 has similar durability as a traditional SMA 11.
Low rolling resistance pavements - potential savings

Savings by using low rolling resistance pavement on 50 km of motorways

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>CO₂</td>
<td>3 300 ton</td>
</tr>
<tr>
<td>Fuel</td>
<td>1,1 million litre</td>
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Total savings of CO₂ when the complete state roads in Denmark has low rolling resistance pavements 160,000 ton per year
Low rolling resistance pavements also reduce noise

<table>
<thead>
<tr>
<th>Reference value dB</th>
<th>SMA 6 L.R.R Pavement</th>
<th>SMA 8 L.R.R Pavement</th>
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<tbody>
<tr>
<td>50 km/t</td>
<td>89 dB</td>
<td>88 dB</td>
</tr>
<tr>
<td>80 km/t</td>
<td>96,5 dB</td>
<td>95,4 dB</td>
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Low rolling resistance pavements – number of years in service before investment becomes a surplus for the society

M14 Motorway to Helsingør
Low rolling resistance pavements - Socioeconomic potentials compared to other initiatives

- Surplus
  - Low rolling resistance pavements
  - Higher requirements for nitrogen utilization for degassed manure

- Deficit
  - Public support for land windmills
  - Public financial support windmills at sea
  - Changing motorway speed from 130 km/h to 110 km/h
What is technical possible

Four test sections has been paved since 2012.

The tests showed:

- That by using low rolling resistance SMA6 and 8 it is possible to obtain a reduction in rolling resistance of 6 and 3 % compared to a traditional SMA8

- Compared to the state roads in Denmark, it is possible to obtain a reduction of app. 20%, equivalent to a fuel saving of app. 6%.

But!

*Within the first two years the tests sections started ravelling.*
Challenges – finding the right balance

- Traffic safety and friction
- CO$_2$ reduction
  - Rolling resistance
The complexity of obtaining equilibrium

Asset Management
Timely implementation
Optimal maintenance

Materials technology
Mix-design
Accelerated tests
Test sections

Molecular understanding
Mechanical modelling
Durability is the key for socioeconomic benefit

- Provide low rolling resistance in entire lifetime
- Does not loose grip
- No ravelling or stone loss
- The pavements material characteristics are stable over time (rutting and climatic impact)
Danish Road Directorate initiated an innovation project with focus on durability for low rolling resistance pavements

New mix design developed in 2016

Purpose:

- New mix design for better workability of the asphalt
- Better texture stability

How to achieve this:

- Changes in the gradation curve
- Change in the active filler (cement, hydrated lime)
- Pre-modified bitumen
The complexity in finding durability

**OBJECTIVE**
1) Improved durability of the Low RR mixtures in the field.
2) Definition of significant bitumen and mixtures characteristics to use for quality control and mixture specifications.
3) Validation of the Low Rolling Resistance properties.

**COOEE project OUTCOME**
1) Use of Pre-modified bitumen
2) Improve texture stability and aggregates interlocking
3) Improve quality of paving operations

**LABORATORY MIXTURES INVESTIGATION**
- Traditional analysis
  - Penetration
  - Softening
- Infrared Spectroscopy
  - Aging
- DSR
  - G* master Curve
  - MSCR
- Workability
  - Gyratory Compactor
- Stiffness Modulus
  - ITSM 10, 20 & 30°C
- Pulling test
  - Stone interlocking

**Bitumen**
- 40/60+P-Flex
- 70/100
- 40/100-75 EL
- 70/100 + P-Flex
- 45/80-55 EL

**Gradation**
- 0-11 standard
- 0-8 standard
- 0-8 COOEE+
- 0-6 COOEE+

**TEST SECTION**
Kalvehave
- Construction
- MPD, Friction and L Profile
- RR measurements

**CIRCULAR ROAD TESTER at VTI**
Accelerated test
- Wearing/Rutting resistance
- Texture evolution
What was done to test durability

- **Laboratory tests**
  - Mix-design
  - Test of bitumen and asphalt (stiffness and adhesion)

- **Accelerated loading tests at VTI in Sweden**
  - Rutting and texture development

- **Test section in 2016**
  - Paving technology
  - Texture, friction and evenness
  - Rolling resistance
Development of rutting from accelerated tests at VTI in 2016

- SMA 11 - standard 4%h
- SMA 8 - standard 4%h
- SMA 8 - COOEE 4%h
- SMA 6 - COOEE - 4%h
Further perspectives

2.5 km of motorways will be paved in June 2017

Depending of support from the government, 50 km of low rolling resistance pavements will be constructed in 2018 and 2019 on motorways in Denmark.

There is a high level of political interest in Denmark to include low rolling resistance pavements to become a supporting mean for reducing CO$_2$ emission.
Challenges concerning measurements of rolling resistance
MIRIAM and ROSANNE projects
Further research initiatives

In 2016 the ROSE project "Road Saving Energy", was initiated, supported by the Danish Innovation

**Partners are:**
Universities RUC and DTU, Danish Road Directorate,
IFSTTAR in France.
Private companies; AfterMath, Continental AG, Greenwood Engineering A/S, NCC Roads A/S, Total Denmark A/S).

**Aim of ROSE:**
Creating the scientific background for a 20% reduction in rolling resistance.

**This will contribute to:**
An additional reduction in fuel consumption.

**If successful the ROSE-project will:**
Lead to a reduction in the energy consumption in Denmark by 1,5%
Thank you for your attention