



# Advanced Asphalt Surface Treatment Technologies using Bio-Based Materials

-Five examples of preservation and asphalt technologies using bio-materials-



喜跃发集团  
XiYueFa Group



Bert Jan Lommerts and QuanXin Xu

# 5 TOPICS OF TODAY

*In chronological order*

1. 1992 - ..... Bio-Fluxed Surface Dressing Binders
2. 2006 - ..... Bio-Based Rejuvenators for high RAP Asphalt Mixes
3. 2008 - ..... Bio-Based Emulsion Enhancer for Various Applications
4. 2012 - ..... Preservation of Porous Asphalt using Bi-Modal Emulsions
5. 2021 - ..... The MicroSeal® Technology for Preservation of Dense Asphalt Pavements

# Bio-Fluxed Bitumen

## *Environmental and Safety Issues of Regular Cutbacks*



1/3 of the solvent evaporates during spraying  
2/3 of the solvent evaporates in the first two years after application  
**Spraying temperature > Flash Point of the (6-8%) Polymer Modified Cutback (SURMAC®)**

# Bio-Fluxed Bitumen

## *Links with Regional Agriculture*



Rapeseed Oil, Groningen, The Netherlands



Castor / Mamona Oil, Pernambuco, Brazil



Sunflower Oil, France



Soy Bean Oil, United States

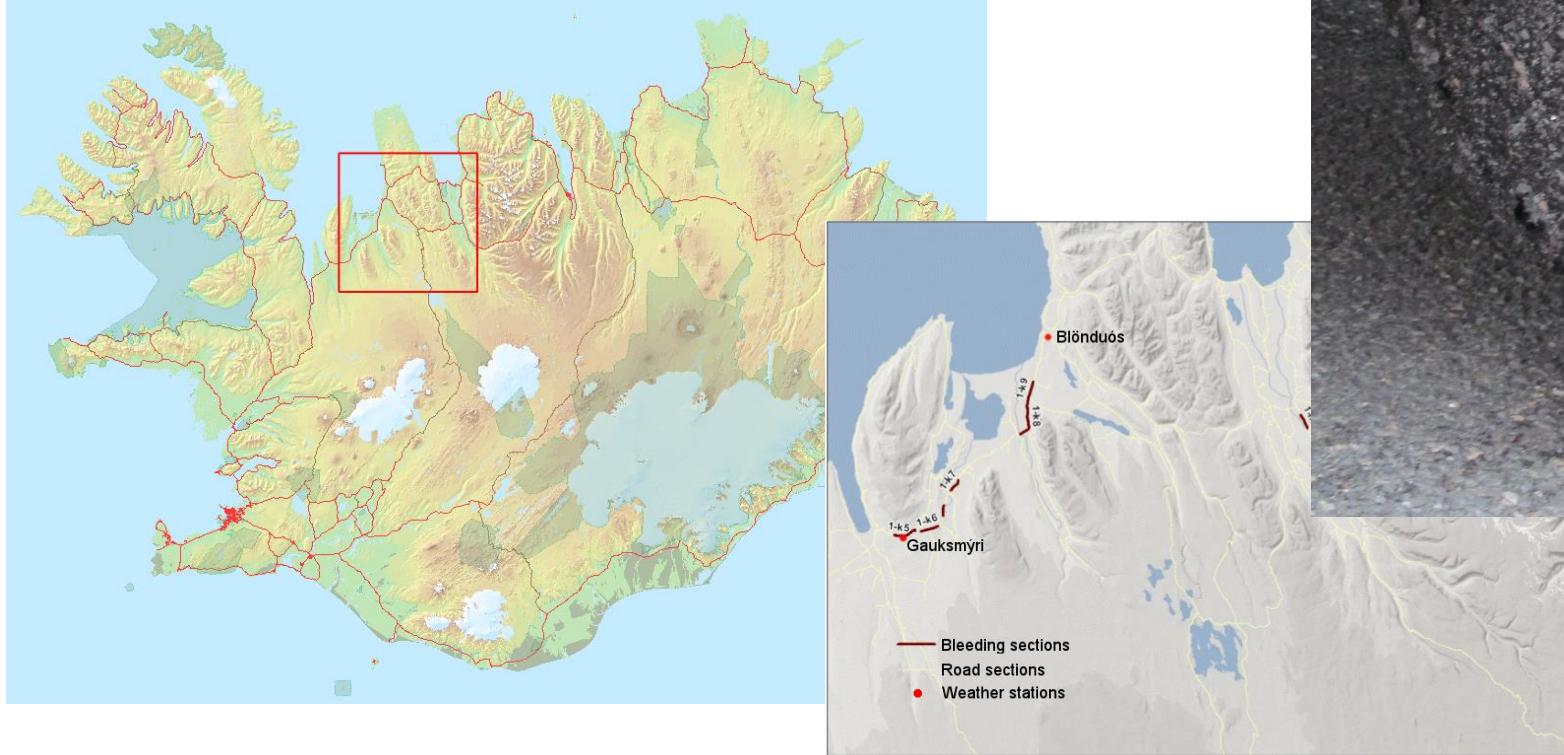


Fish Oil, Iceland

Vegetable oils are used as:  
Pure plant oils (PPO), high viscosity  
Esters (methyl or ethyl), low viscosity

# Bio-Fluxed Bitumen

## *How to Avoid Bleeding Issues*



Courtesy of: ARNAR ÁGÚSTSSON and NICOLE KRINGOS

# Bio-Fluxed Bitumen

## *Environmental and Safety Issues of Regular Cutbacks*



< 1980

Tar-bitumen



1980 – 2000

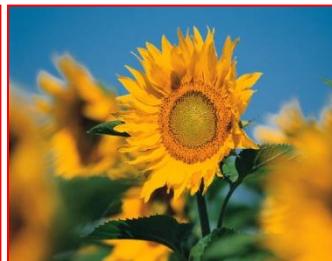
Polymer  
modified  
cutbacks

(Astor-Stag, UK)



> 1995

Rapeseed oil  
(Vialit, Austria)



> 2000

Sunflower  
methyl ester +  
siccative catalyst

(Appia, France)



> 2002

Rapeseed  
methyl ester  
+ special additive

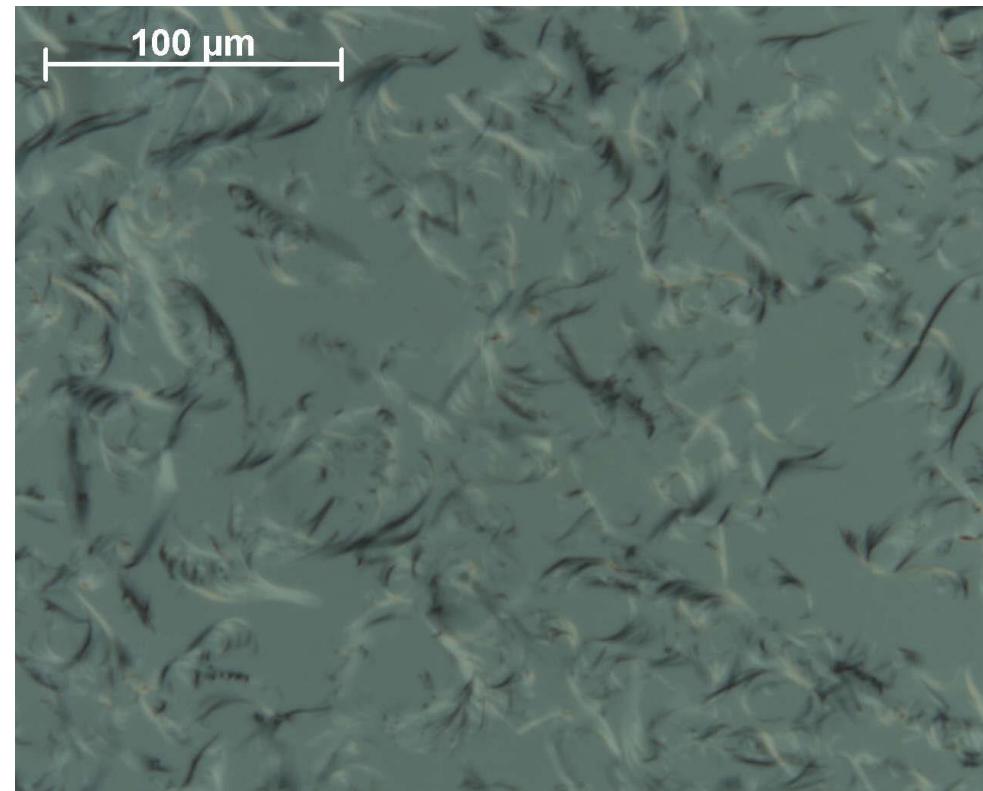
(Latexfalt, the  
Netherlands)

**SURMAC®**

**SURMAC® ECO**

# Bio-Fluxed Bitumen

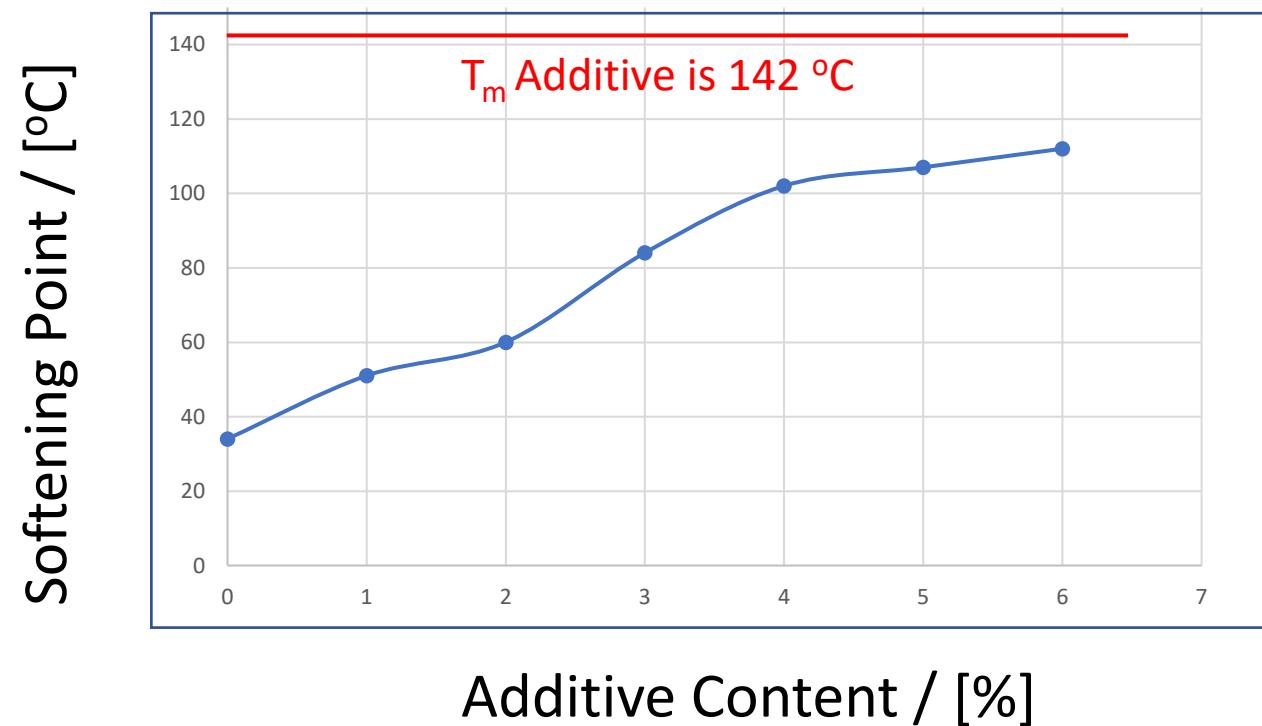
## *Gel-Crystallization*



3 wt. % organic additive [ $T_m \approx 142^\circ\text{C}$ ]  
crystallized from a polymer modified bitumen/RME (95/5) blend

# Bio-Fluxed Bitumen

## *Improved Bleeding Resistance*



# Bio-Fluxed Bitumen

## *Excellent Wetting Ability*



Rapeseed  
Methyl ester  
Viscosity  
STV = 21 sec

Kerosine +  
Bright Stock  
Viscosity  
STV = 20 sec

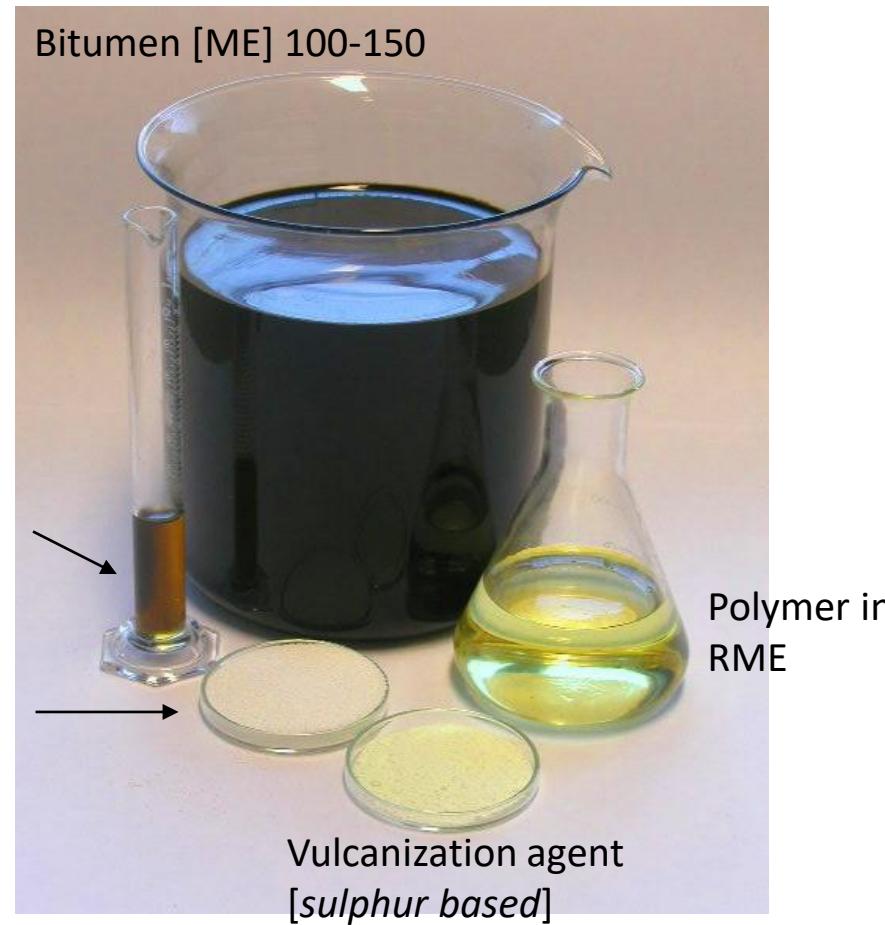
Migration of Diluents (dyed with 1 wt. % of bitumen) into a  
“standardized” sand after 3 hours at ambient temperature.

# Bio-Fluxed Bitumen

## *The Formulation of SURMAC® ECO*

Adhesion promoter [*for application at low temperatures*]

Softening point booster [*organic additive*]



# Bio-Fluxed Bitumen

## *Application of Bio-Fluxed Bitumen*



SURMAC® ECO has been successfully introduced in various countries, however, the substitution by bitumen emulsions is still ongoing.

# Bio-Based Rejuvenators

## *How to Create a Circular Asphalt Industry: Recycling*



### The Netherlands:

Recycling in Top Layers is becoming important in the next 5-10 years. From 10-30% RAP re-use in top layers to > 60% RAP re-use/recycling in the years to come.

### China:

Down-cycling of RAP into base layers and foundation layers is still ongoing, loss of value. 10% of the 130 Mtons of RAP generated is only effectively used

# Bio-Based Rejuvenators

## *How to Select the right Rejuvenator, Price-Performance*

↑ Quality?



Vegetable Esters/Oils



€100 – €5000 / 1000 kg

[Chemically modified] BioBased materials

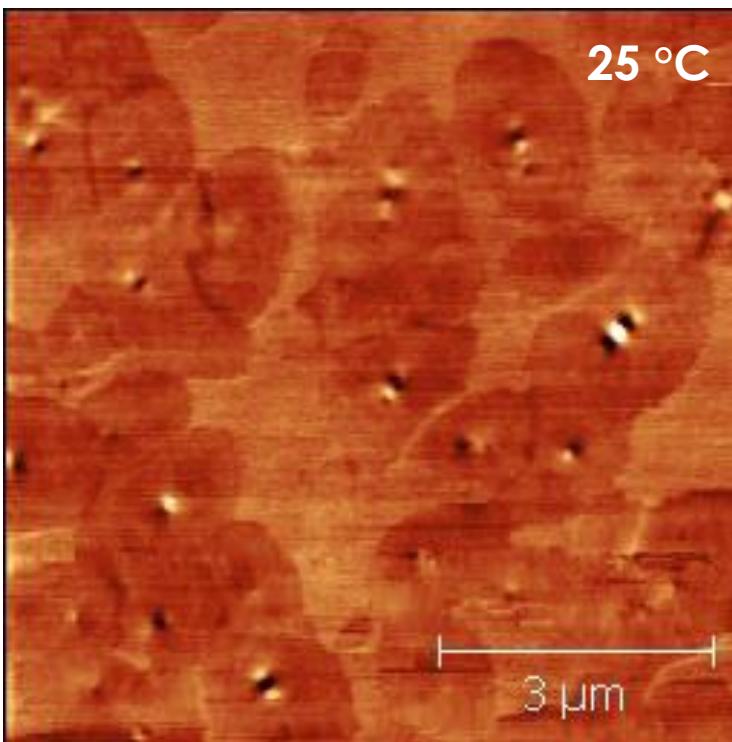


Price €

# Bio-Based Rejuvenators

## *Effect of Ageing*

70-100 bitumen



25 °C

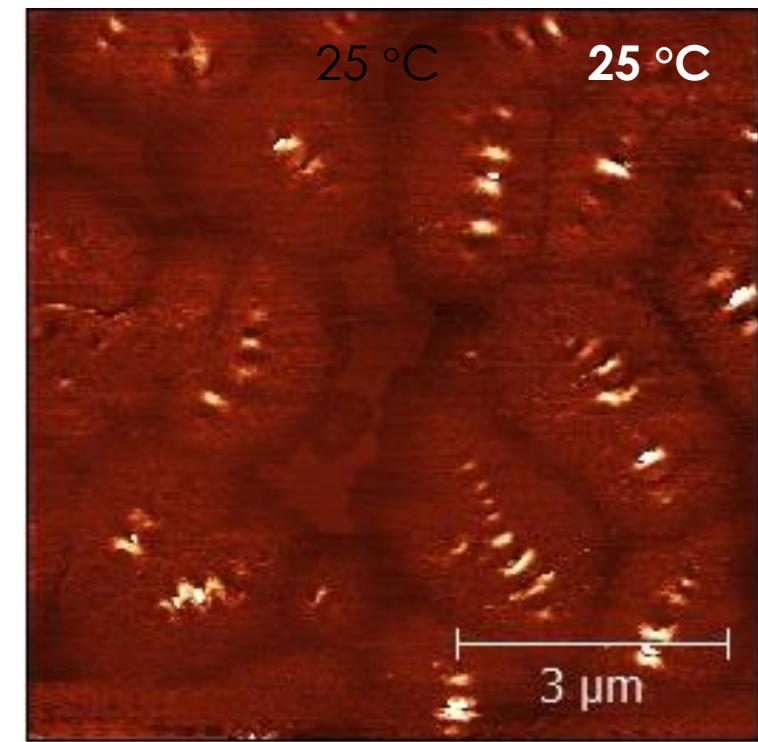
Increased Asphaltene content

Increased polarity of the Asphaltene-rich phase

Less compatibility between Maltene and Asphaltene-rich phase

Increased stiffness of the Asphaltene-rich phase

After PAV ageing

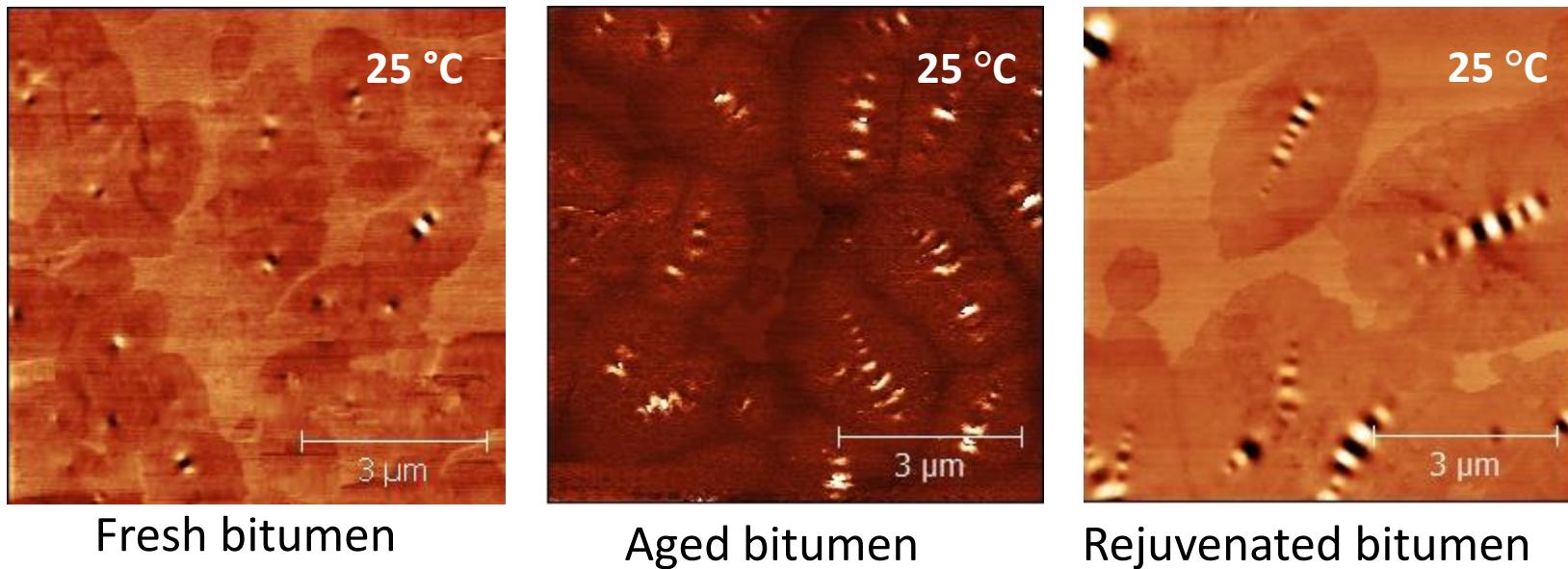


25 °C

25 °C

# Bio-Based Rejuvenators

## *Fundamental Studies on Ageing and Rejuvenation of Bitumen*



**Re-dispersion** of aggregated asphaltenes is required!

Fundamental studies have shown that there is a pronounced difference between softening and re-dispersion of “segregated” asphaltenes in aged bitumen.

# Bio-Fluxed Bitumen

*The "Honey" Model for the Rejuvenation of Aged Bitumen*



Fresh Honey



"Rejuvenation"



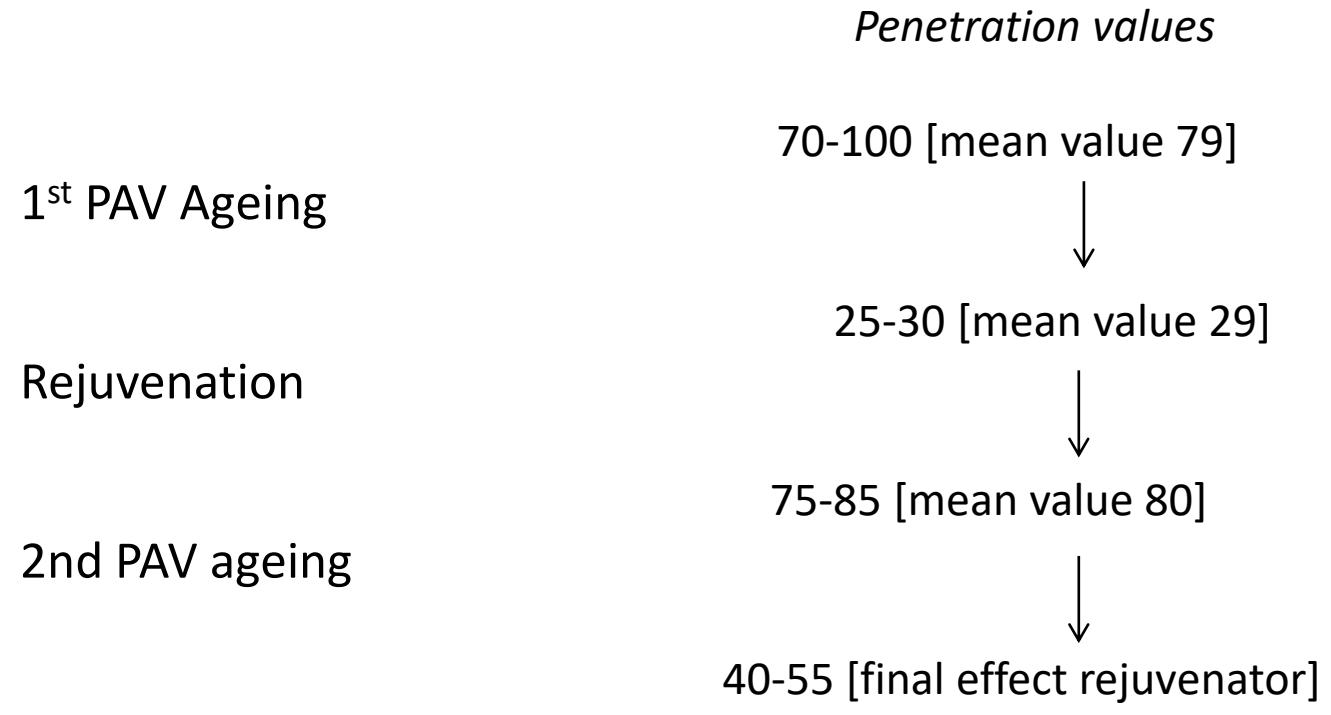
"Aged" Honey



"Rejuvenated" Honey

# Bio-Based Rejuvenators

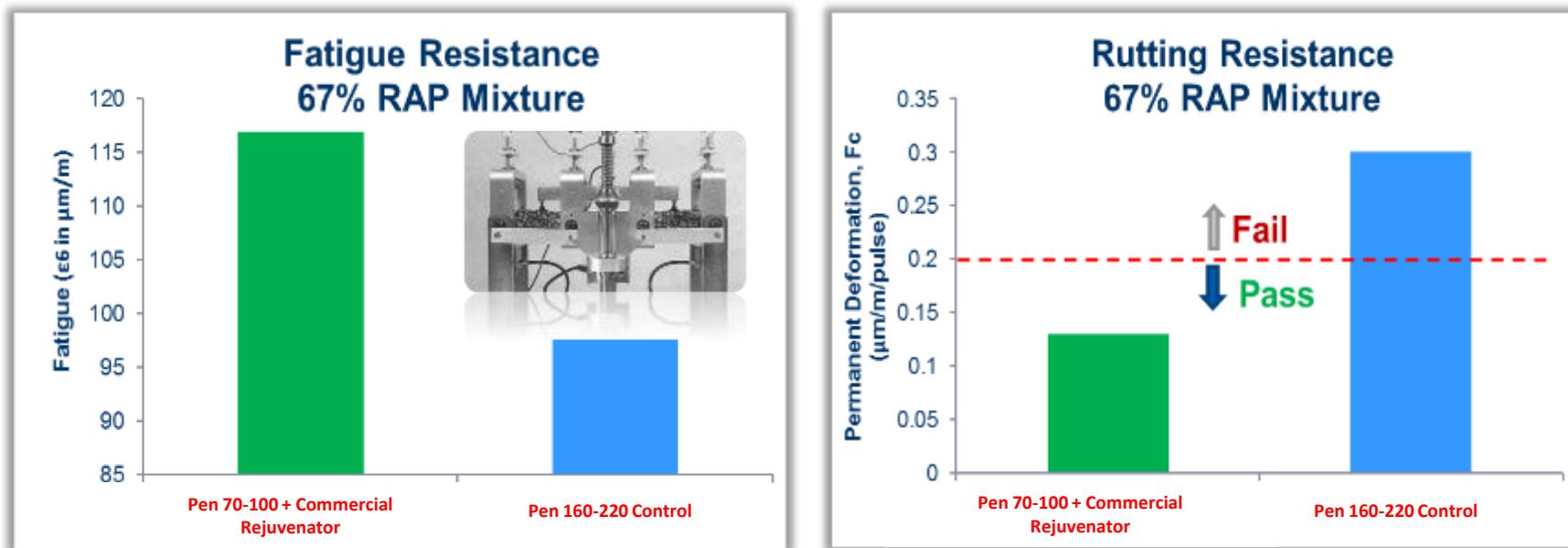
*Rejuvenated Bitumen has a Higher Resistance towards Ageing*



Similar result at the molecular level

# Bio-Based Rejuvenators

## *Well-Balanced Low and High Temperature Performance*

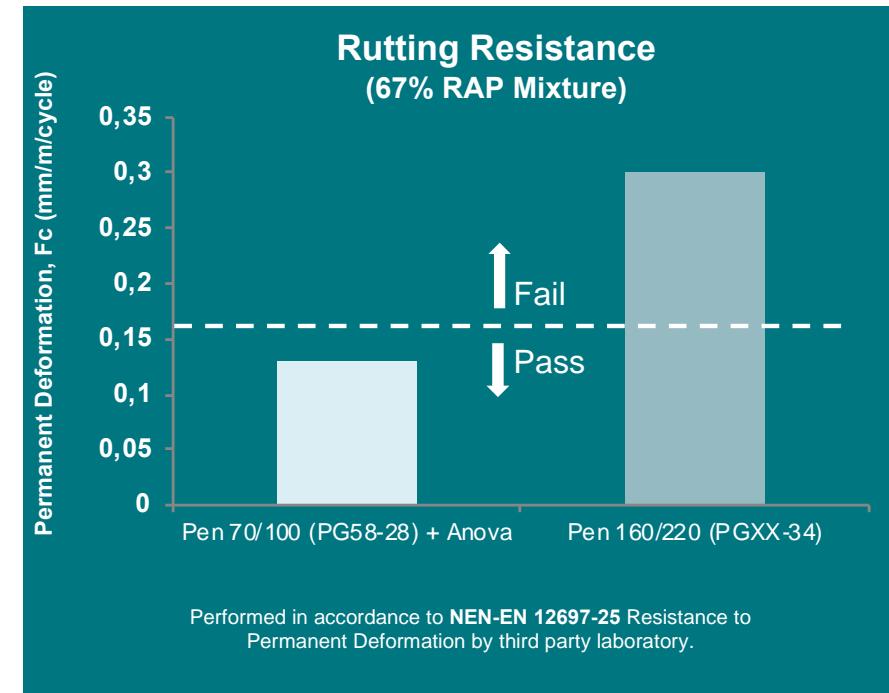
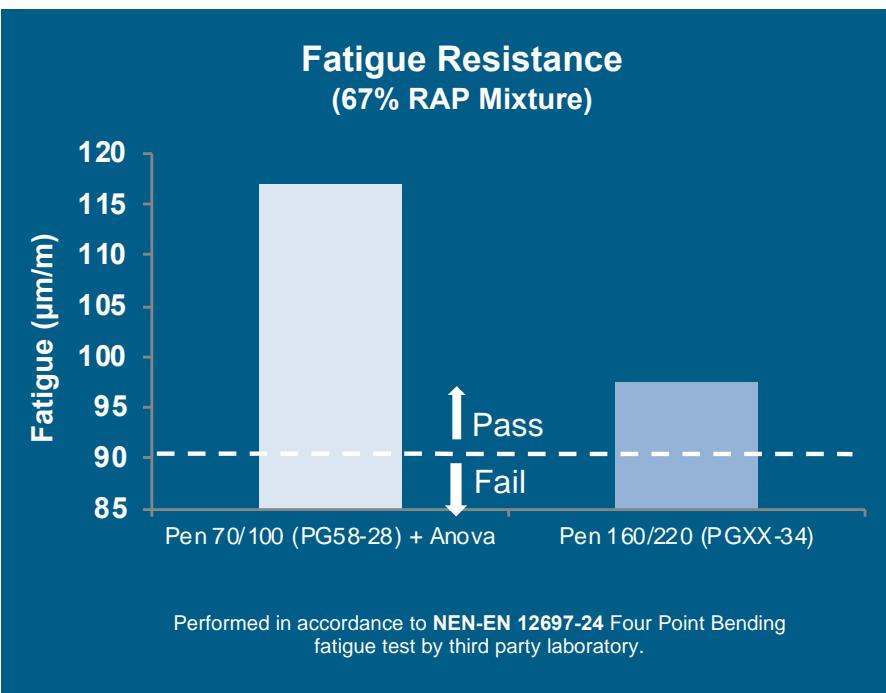


Courtesy of: **HASSAN TABATABAEE**



# Bio-Based Rejuvenators

## *100% Recycling is within Reach*



# Bio-Based Rejuvenators

*Dosing is Easy*



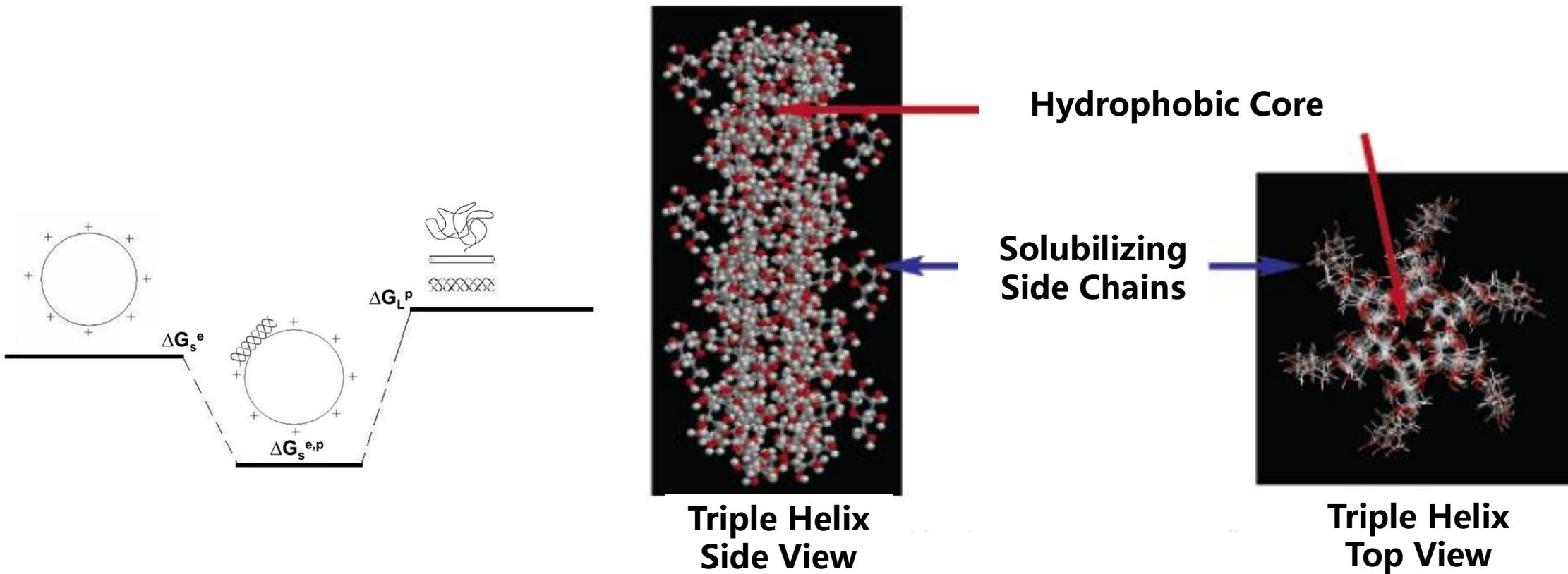
Sprayed onto RAP

Mixed into Bitumen

Injection into pugmill

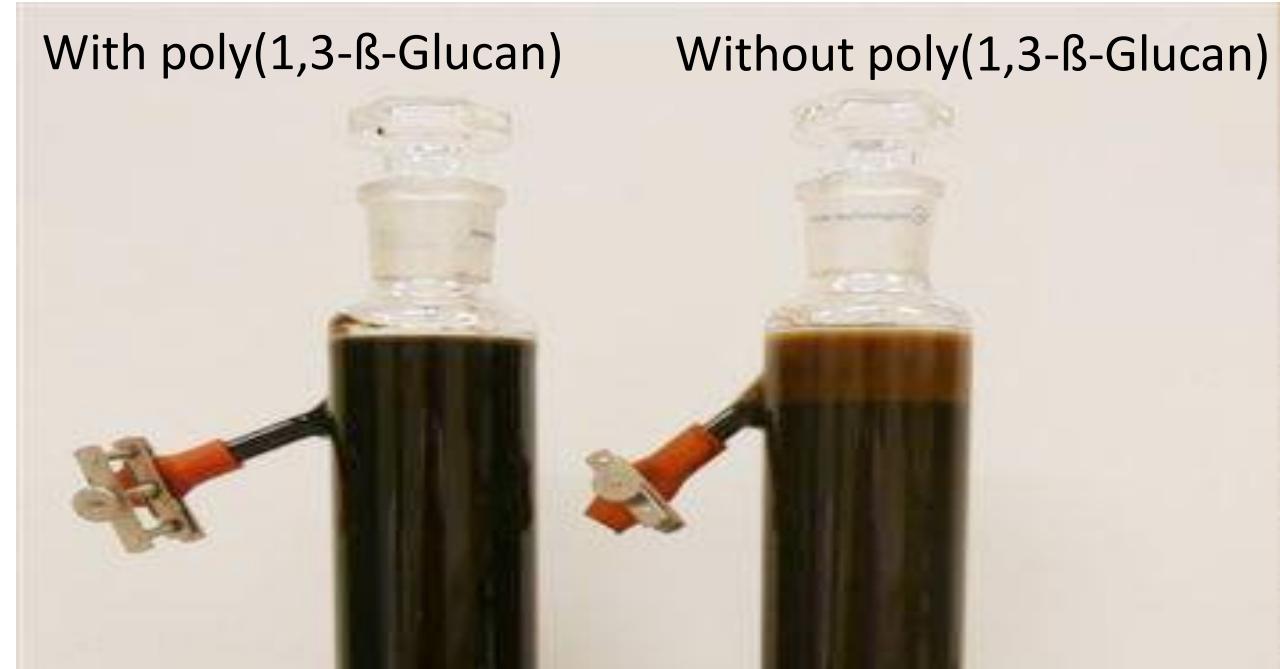
# Bio-Based Emulsion Enhancer

## *Low Penetration and Highly Polymer Modified Emulsions*



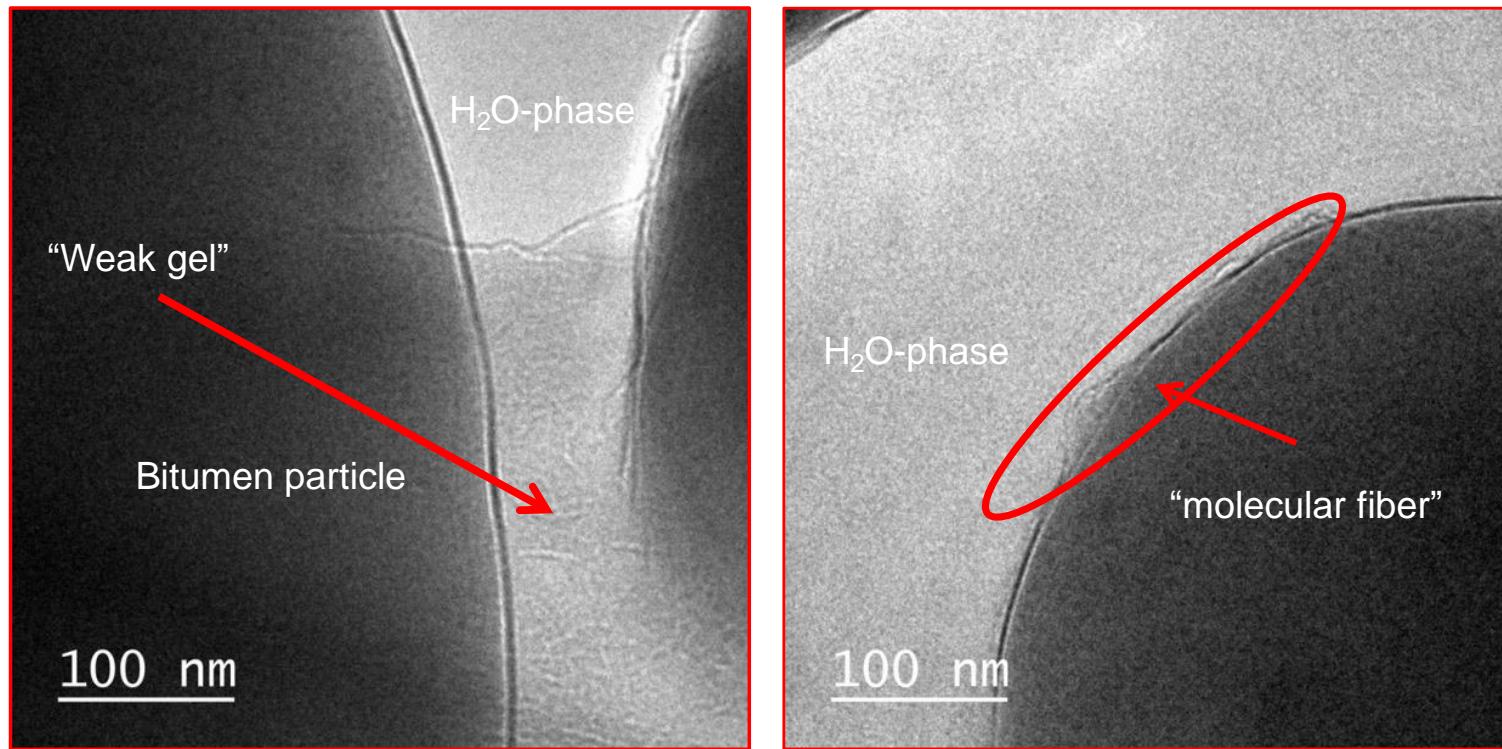
# Bio-Based Emulsion Enhancer

*Storage Stability of Emulsions is Significantly Improved*



# Bio-Based Emulsion Enhancer

## *Stabilization via Weak Gel and Selective Absorption*



Courtesy of: **SAIDA EI ASJADI AND STEPHEN PICKEN**

# Bio-Based Emulsion Enhancer

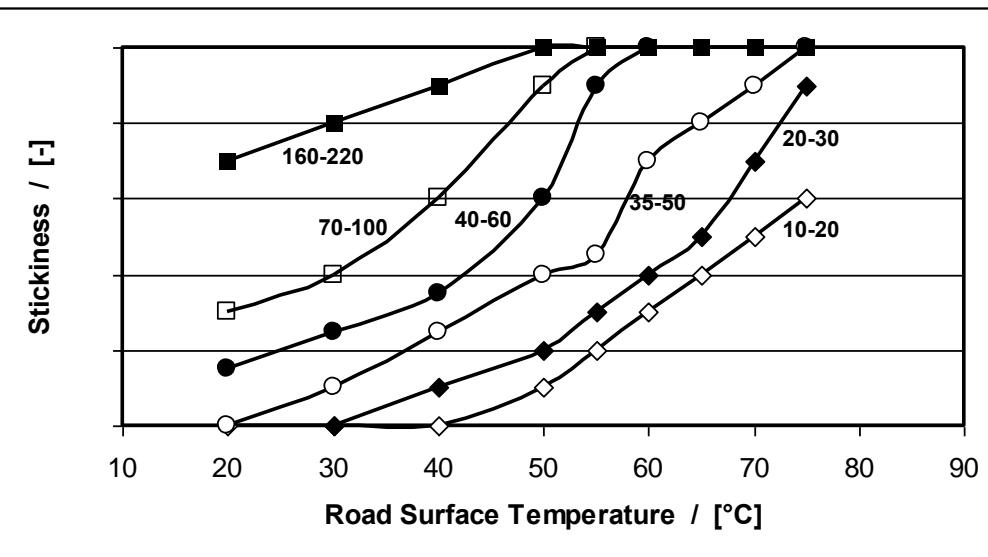
## *Application of Trackless, Fast Breaking Tack Coats*



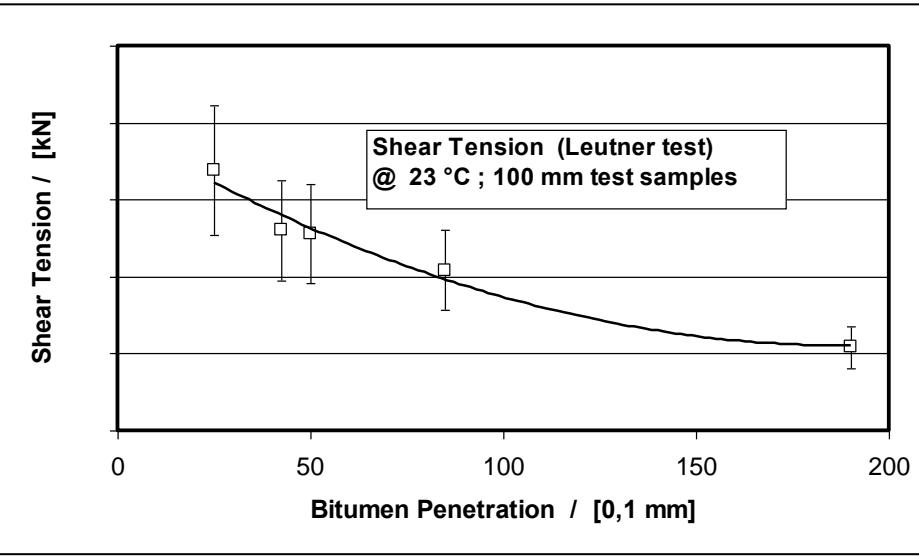
Application of a  
**FAST BREAKING**  
**<< 20 MINUTES**  
  
**LOW PENETRATION**  
**20-30 [0.1 mm]**  
  
Cationic Emulsion

# Bio-Based Emulsion Enhancer

## *Fast Breaking, Low Penetration, High Strength Tack Coats*



Non-Sticky, Low Penetration

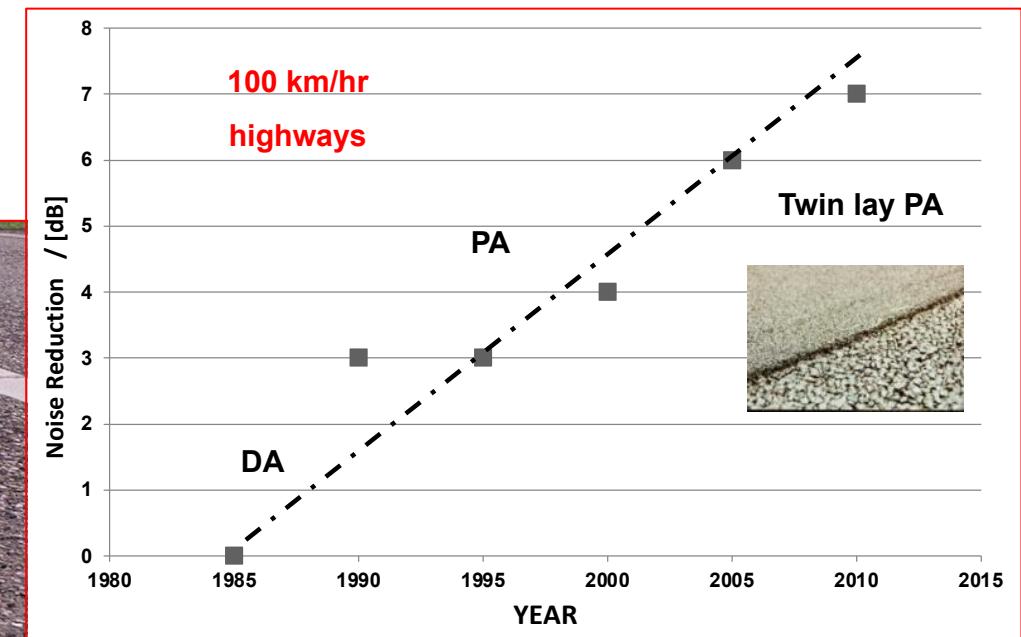


High Shear Strength (Leutner Test)

NL: penetration 35-50 [0.1 mm]  
Fr: penetration 20-30 [0.1 mm]

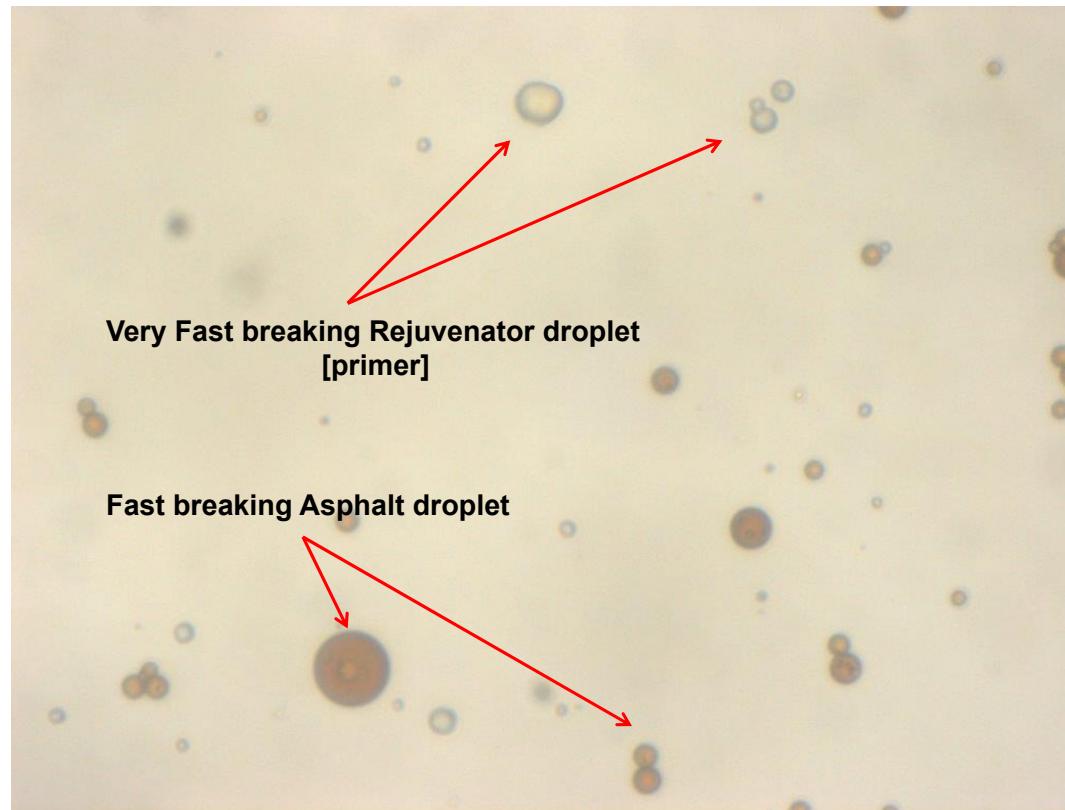
# Preservation of Porous Asphalt

## *Noise Reduction Important, How to avoid Stone Loss*



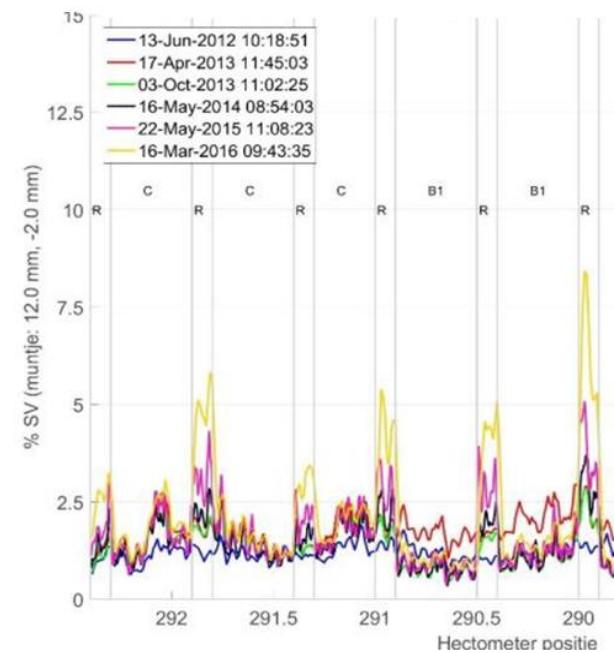
# Preservation of Porous Asphalt

## *Microscopic Image of a Bi-Modal Emulsion*



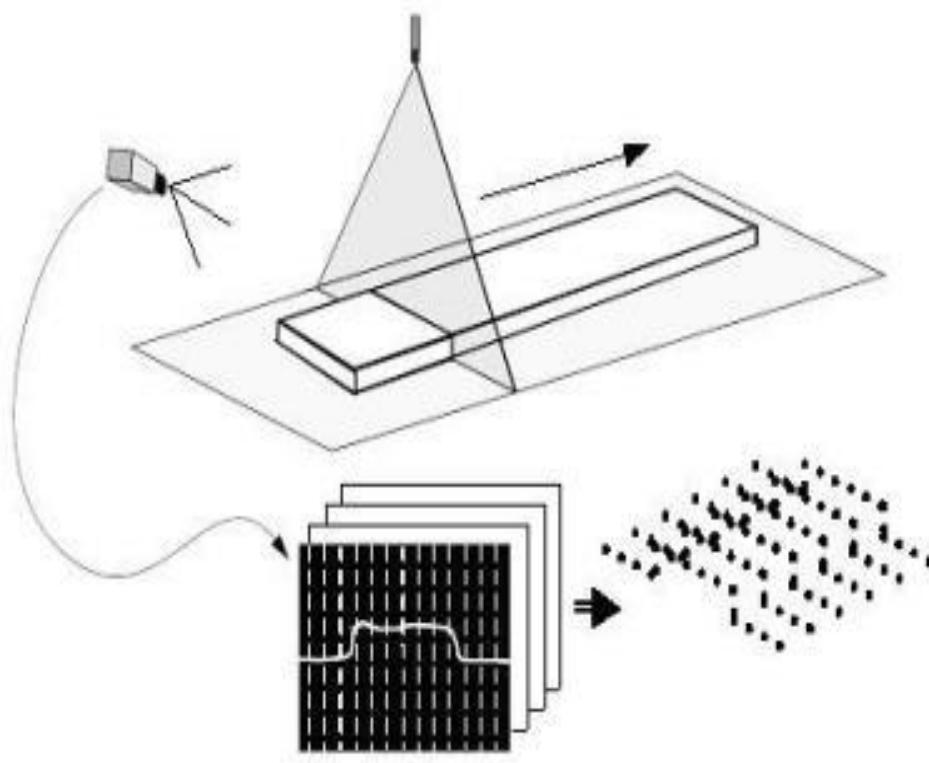
# Preservation of Porous Asphalt

## *Application of the Bi-Modal Emulsion*



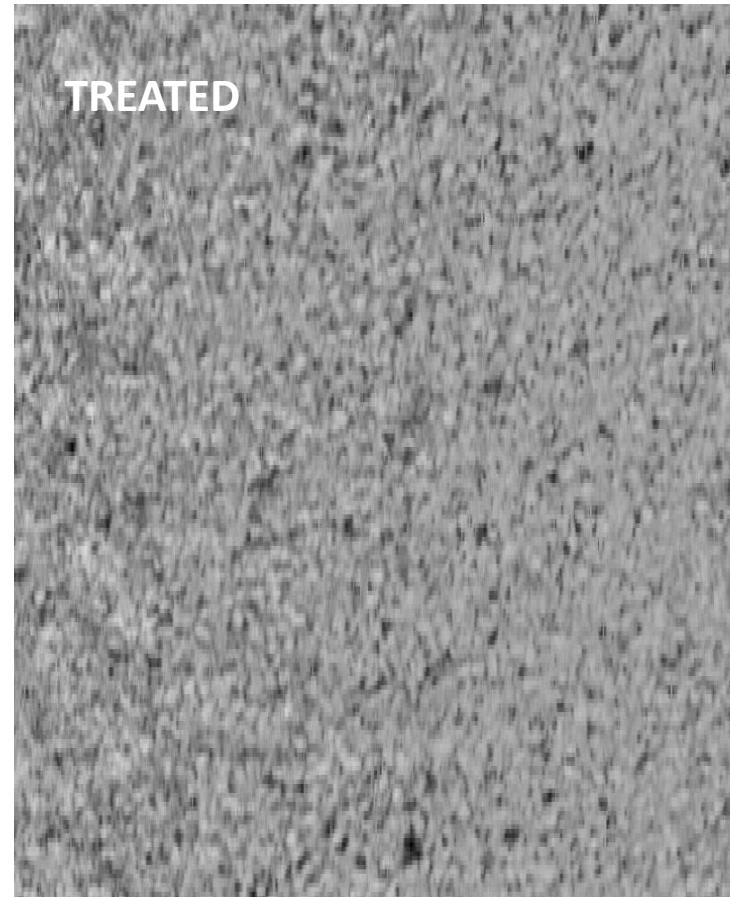
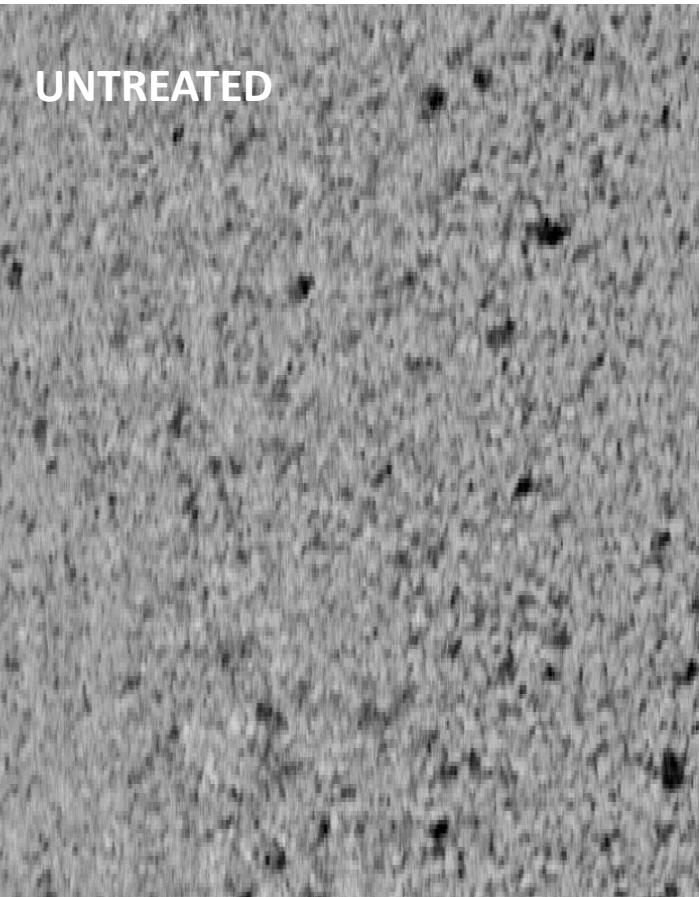
# Preservation of Porous Asphalt

## *High Resolution LCMS, GPS Positioning to Measure Stone Loss*



# Preservation of Porous Asphalt

## *LCMS Monitoring of PA for a period of 6 Years*

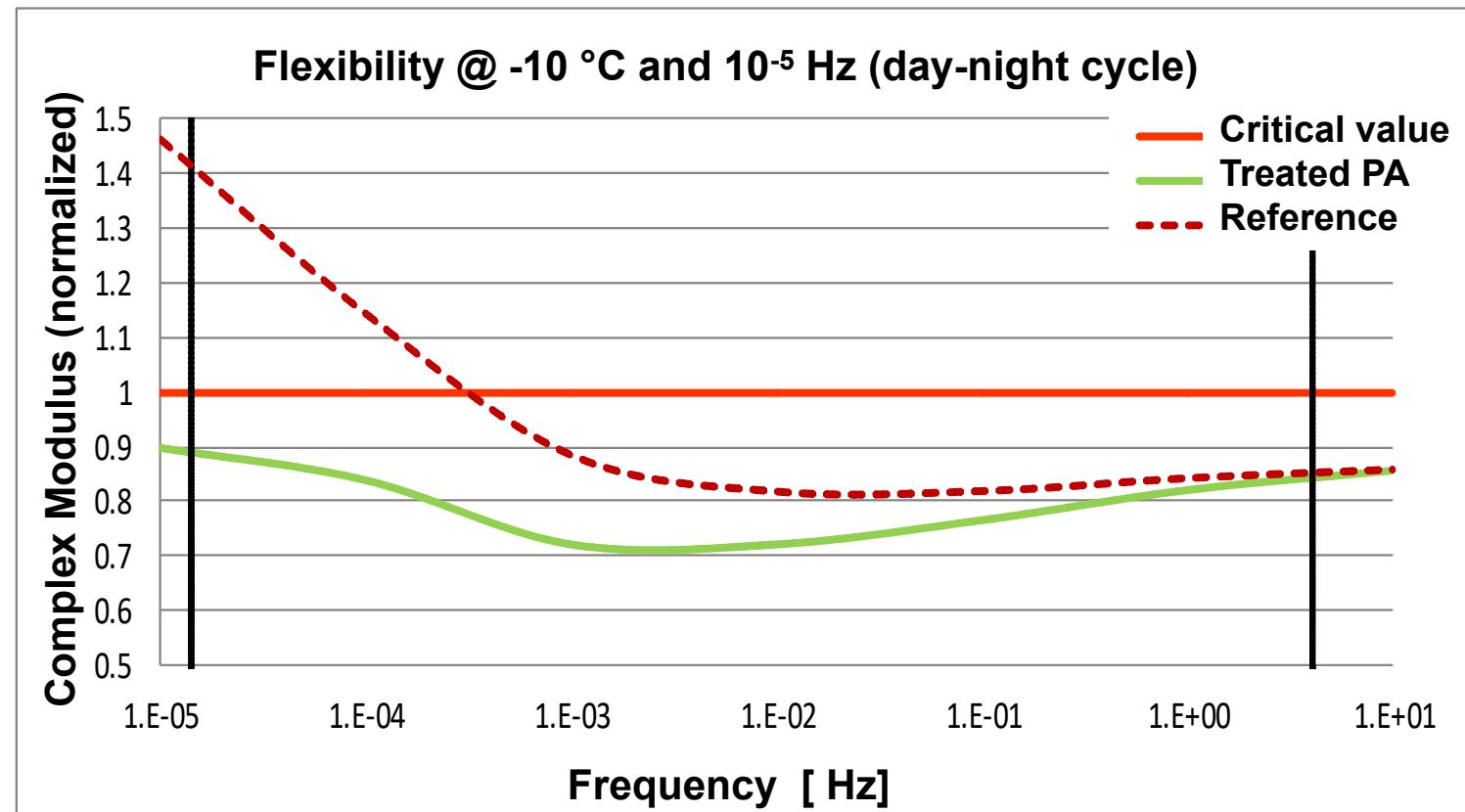


Application in Year 7, 1 year  
before the onset of ravelling  
was predicted

Results: 50% increase in  
service life from 11 years to  
17 years

# Preservation of Porous Asphalt

## *Improved Flexibility at Low Temperatures, Reduction of Stone Loss*



Mastic recovered  
from the Treated  
Section of the A73,  
the Netherlands

# Preservation of Dense Pavements

## *The new MicroSeal Technology*

MicroSeal =

A sprayable, 40-50% sand filled fog seal/surface dressing

Special Emulsification System

Abrasion resistant bitumen formulation

Non sticky, temperature resistant bitumen formulation

40-50% filled with selected ultra black sand

***Spraying at night, time slot 11 pm – 5 am, > 5 km's per night.***



**Beijing, Black and Bright project**

**Product is under development for the third ring road in Beijing, China**

# Preservation of Dense Pavements

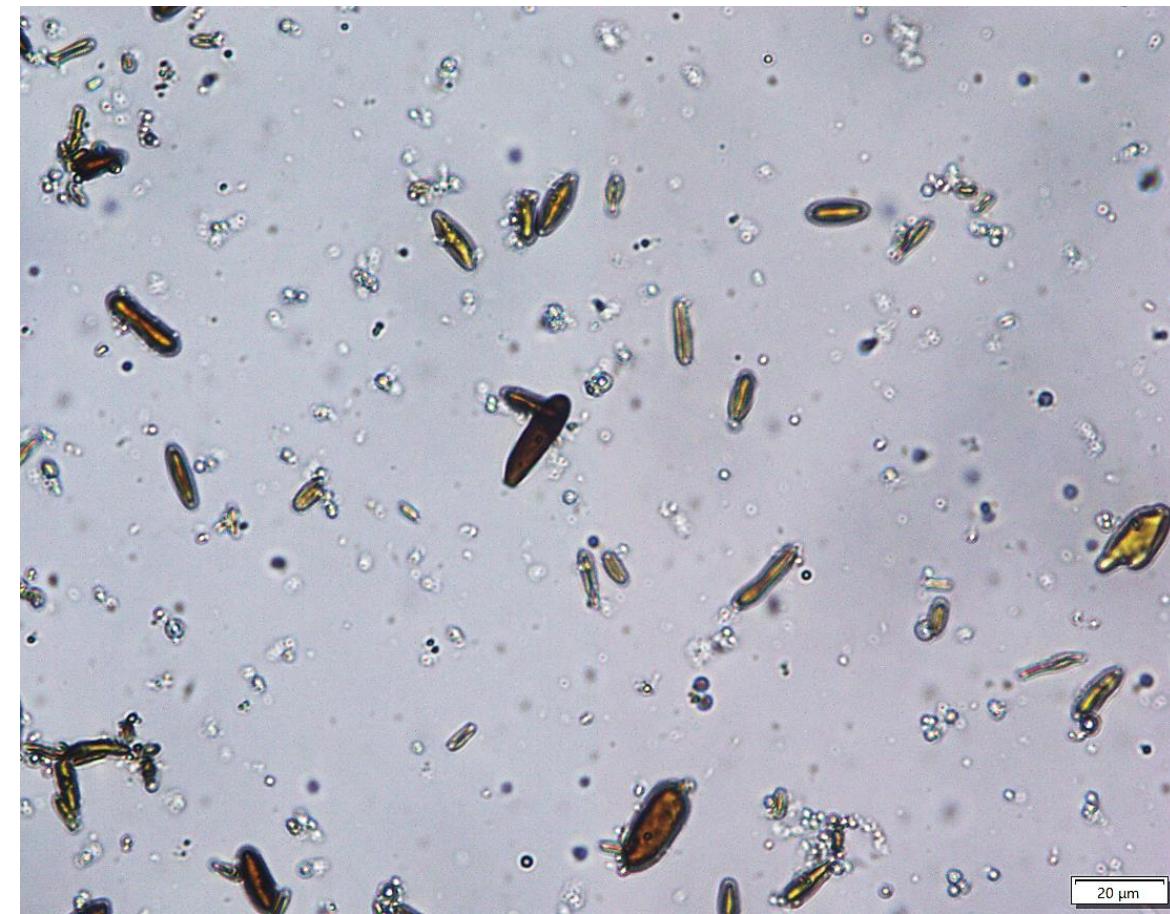
## *Microscopic image of a dilute MicroSeal Emulsion Mixture*

### Multi-modal emulsion

Containing  
rejuvenator,  
bitumen emulsion,  
polymer modification

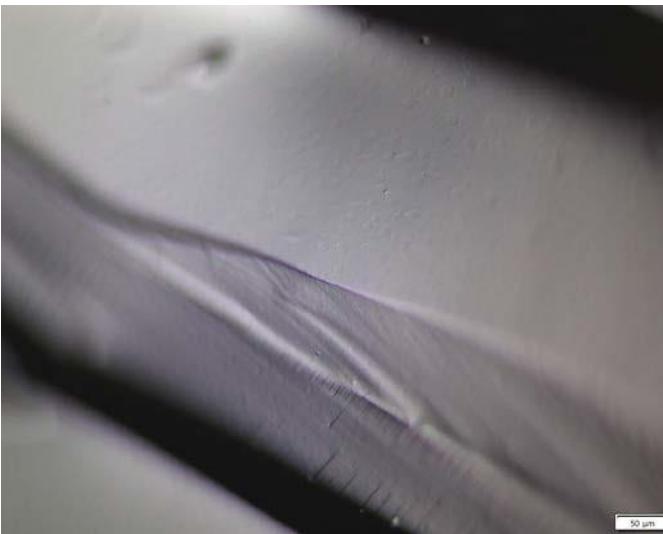
and

sand (2-3 mm)

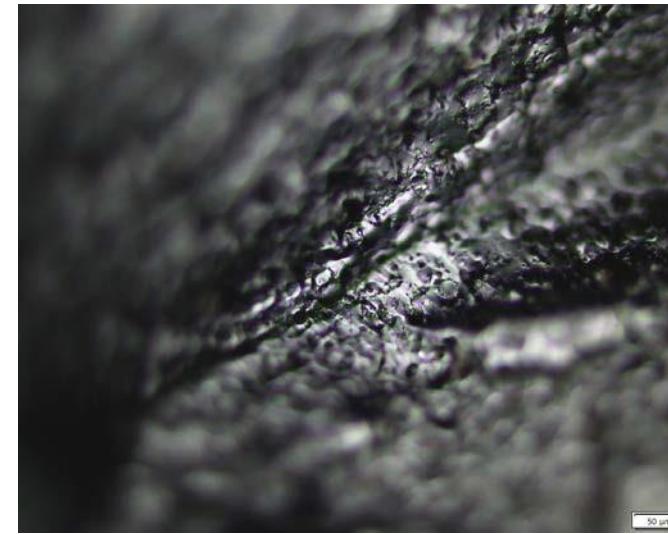


# Preservation of Dense Pavements

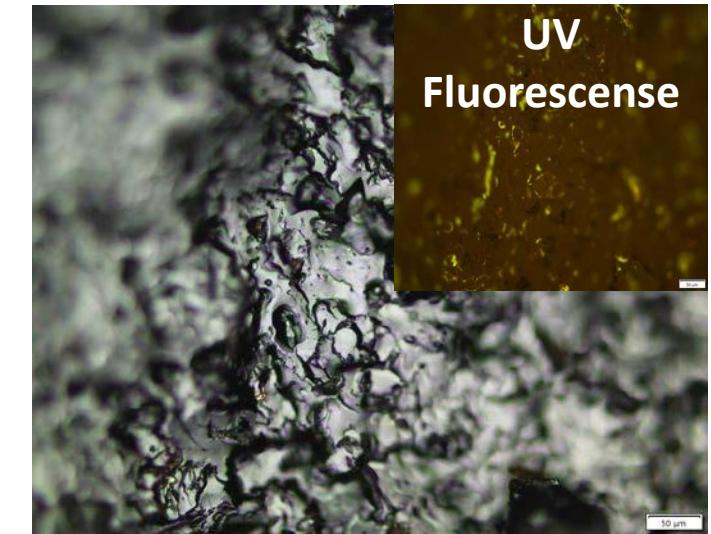
*A comparison study between three types of bitumen systems*



Regular bitumen 70-100



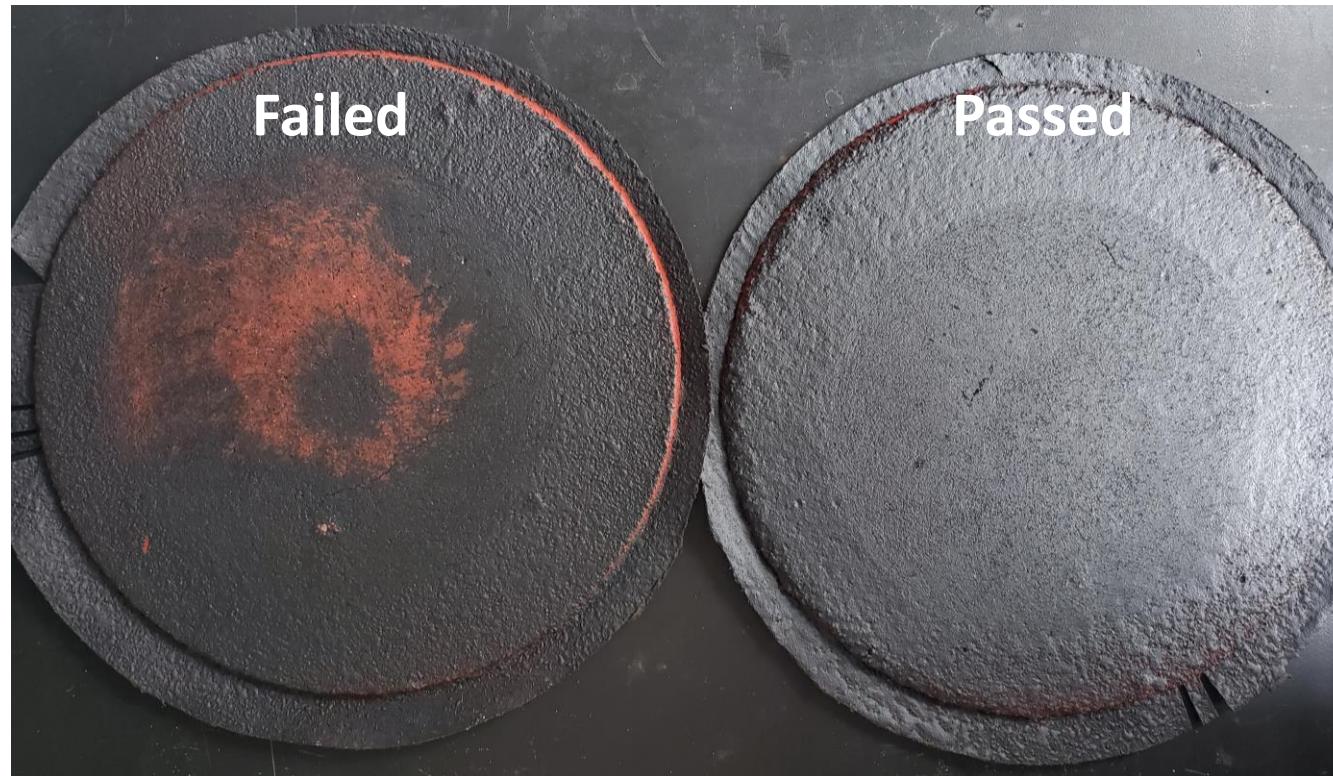
Selected low penetration bitumen



Polymer modified selected bitumen

# Preservation of Dense Pavements

*Abrasion Test, Similar to the ISSA Test*



Regular Bitumen

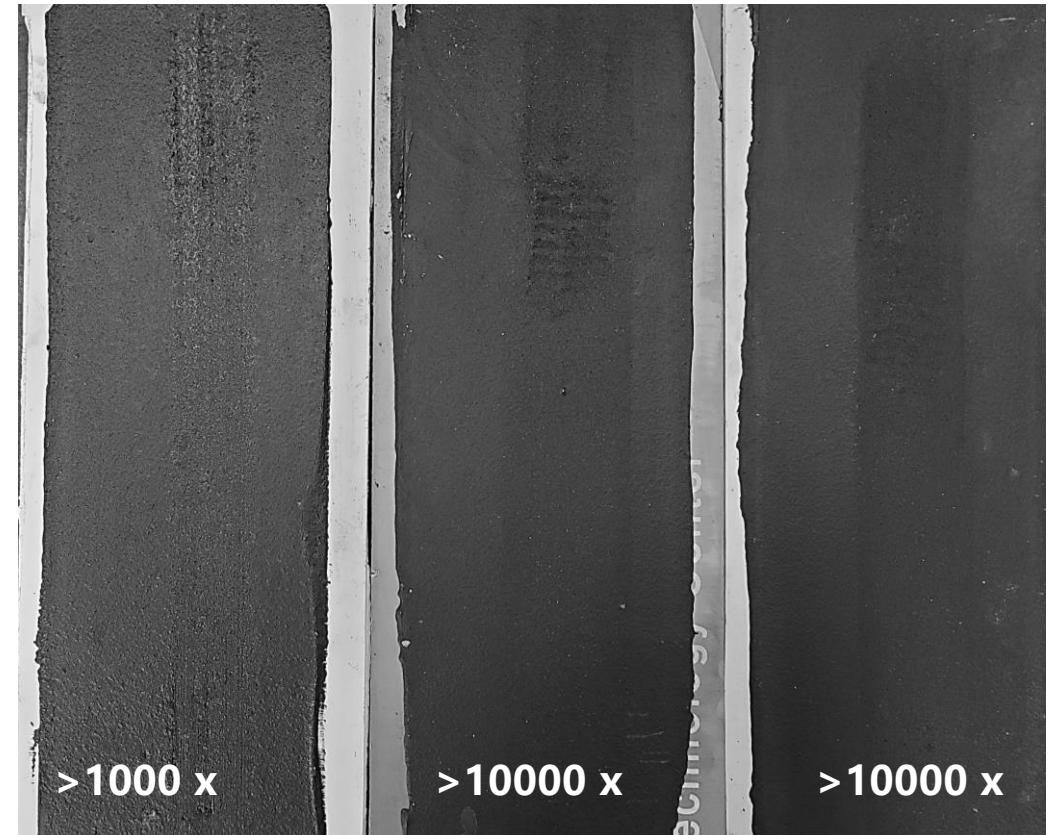
Selected Polymer Modified Bitumen

# Preservation of Dense Pavements

## *The new MicroSeal Technology*



Metal Brush Abrasion, Coating Test



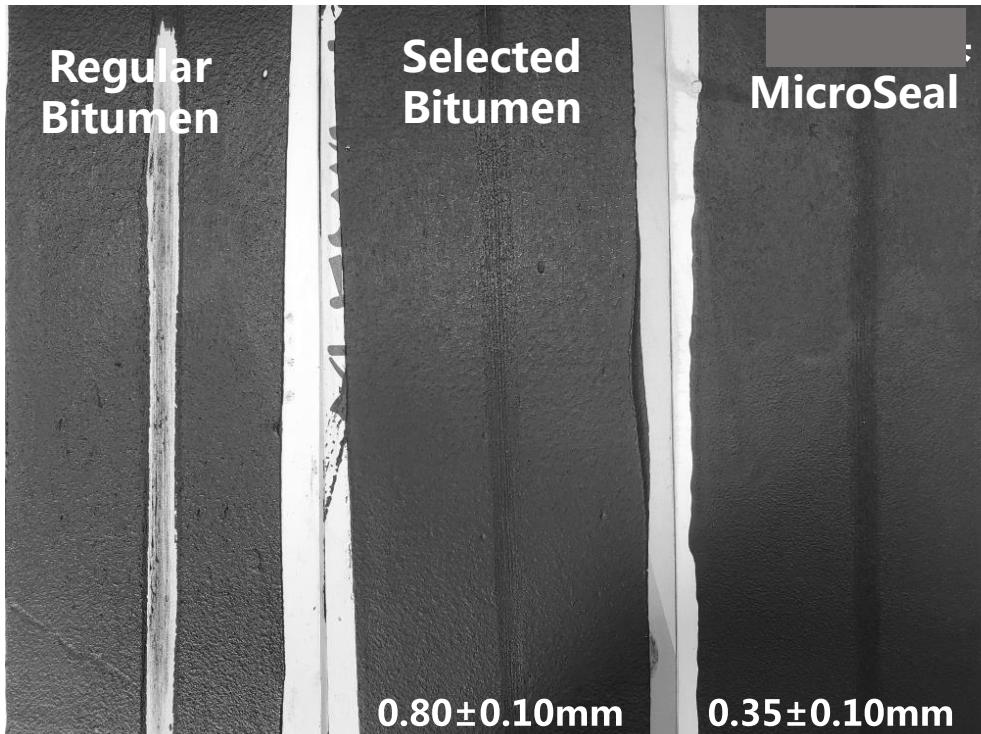
Regular  
Bitumen

Selected  
Bitumen

MicroSeal

# Preservation of Dense Pavements

## *Harsh Track Test Using Rubber Band*



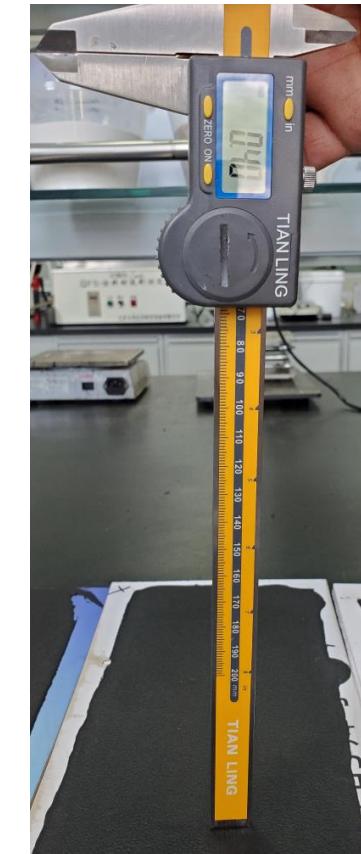
<300 x

$0.80 \pm 0.10\text{mm}$

$0.35 \pm 0.10\text{mm}$

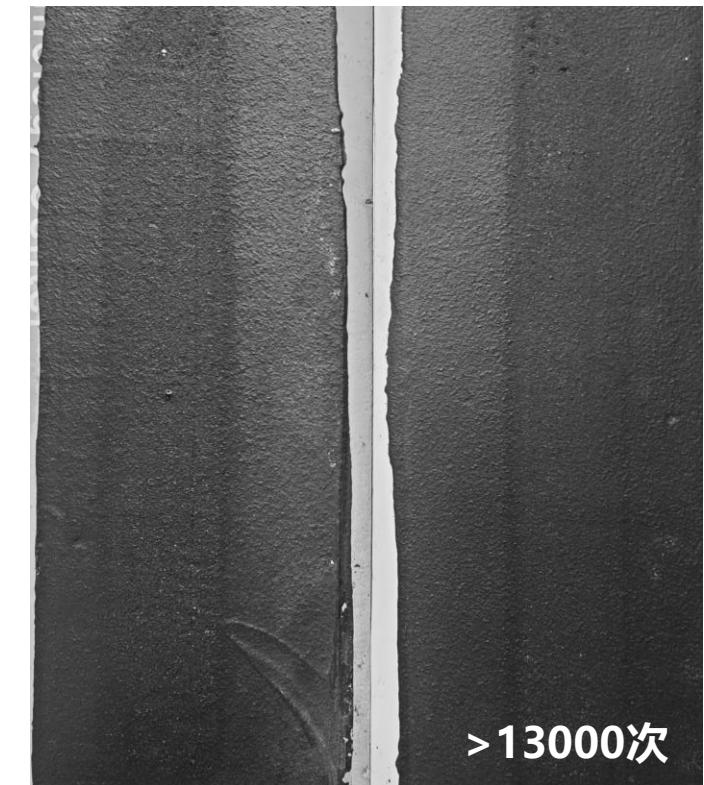
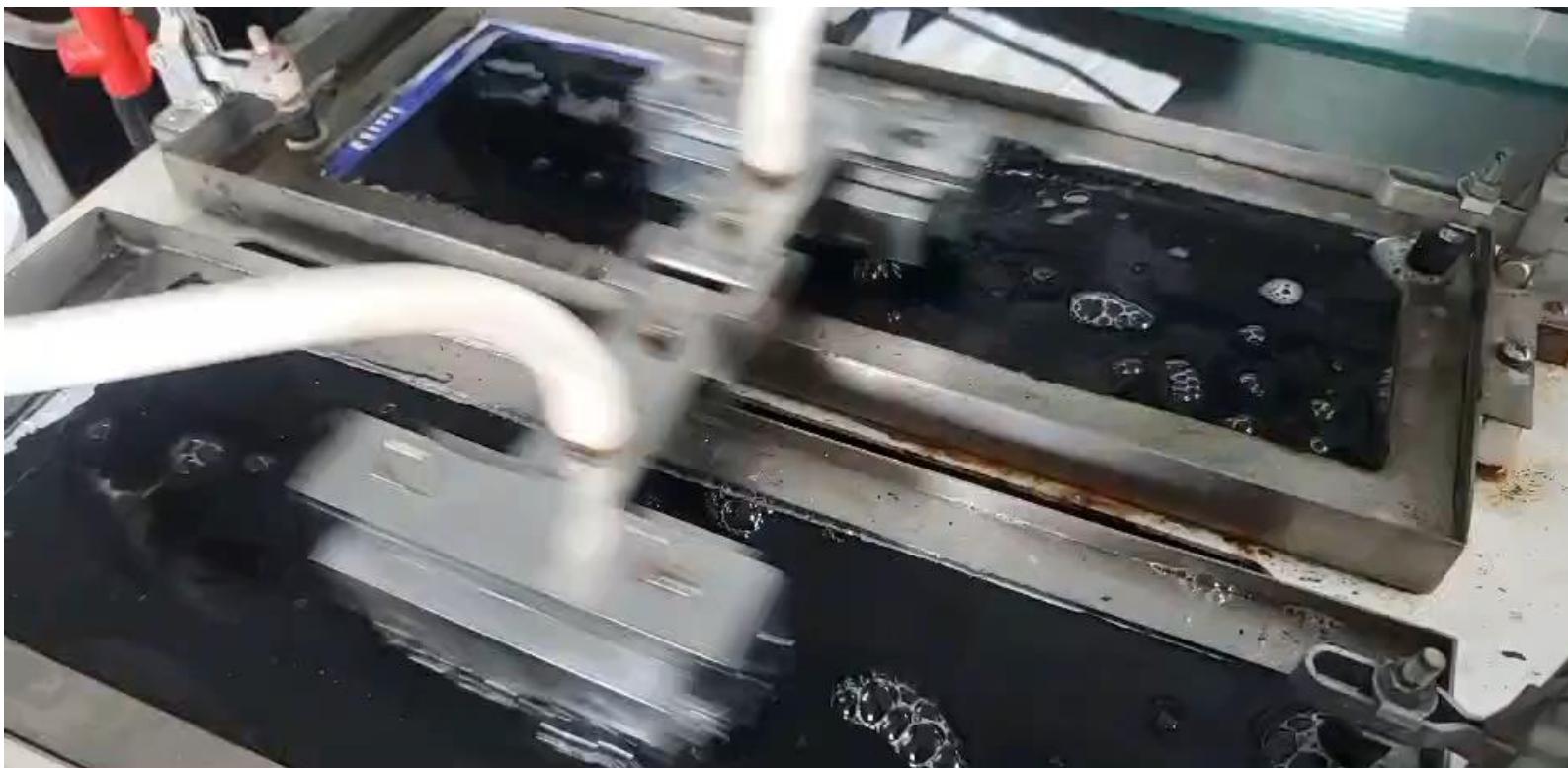
>1000 x

>>1000 x



# Preservation of Dense Pavements

## *Soap-Water Resistant Test*

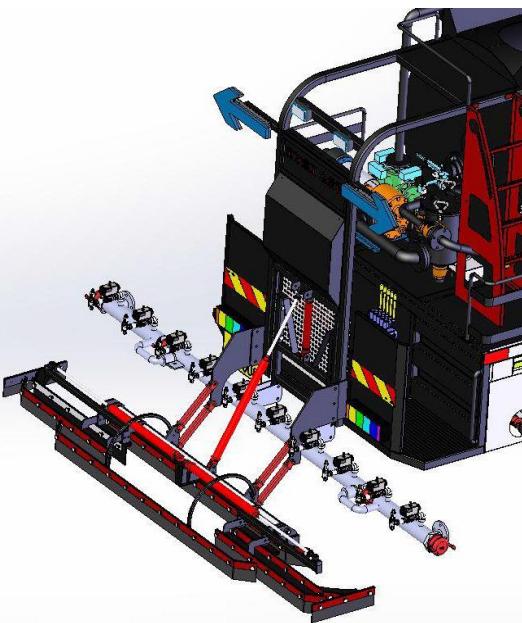


Selected  
Bitumen

MicroSeal

# Preservation of Dense Pavements

## *Continuously Mixed Spray Tanker*



# Preservation of Dense Pavements

*Trials, July 2021, ShanDong Province, China*



Application



Result

# Preservation of Dense Pavements

## *Spray Rate*

**Advised Spray Rate**

0.7 – 1.3 kg/m<sup>2</sup>

Double Layer dressing  
Is possible



# Preservation of Dense Pavements

## *Air Jet Spraying for Vertical Surfaces (e.g. Concrete Protection)*



# Preservation of Dense Pavements

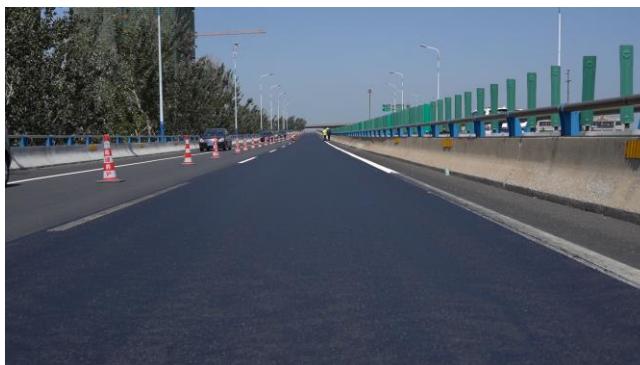
## *The new MicroSeal Technology*



- Excellent Wear Resistance
- Good Thermal Resistance
- Fast Drying Time (< 20 minutes)
- Good Anti-Skid Performance
- Good Water Proofing Ability
- Rejuvenation Capability
- Good Adhesion to Asphalt Surface
- No bleeding or Stickiness Issues
- Cheap and Easy to Apply
- **Future looks promising**

# Preservation of Dense Pavements

## *The new MicroSeal Technology*



谢谢

danke  
thanks

takk fyrir

tak

obrigado

dank  
merci

Благодарность

## Advanced Asphalt Surface Treatment Technologies using Bio-Based Materials

-Five examples of preservation and asphalt technologies using bio-materials-

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