

The background of the slide is a blue line drawing sketch of a landscape. It shows rolling hills, a body of water, a small building with a chimney, and various trees. The drawing is done in a simple, sketchy style with blue ink on a white background.

Experiences with WMA in Sweden

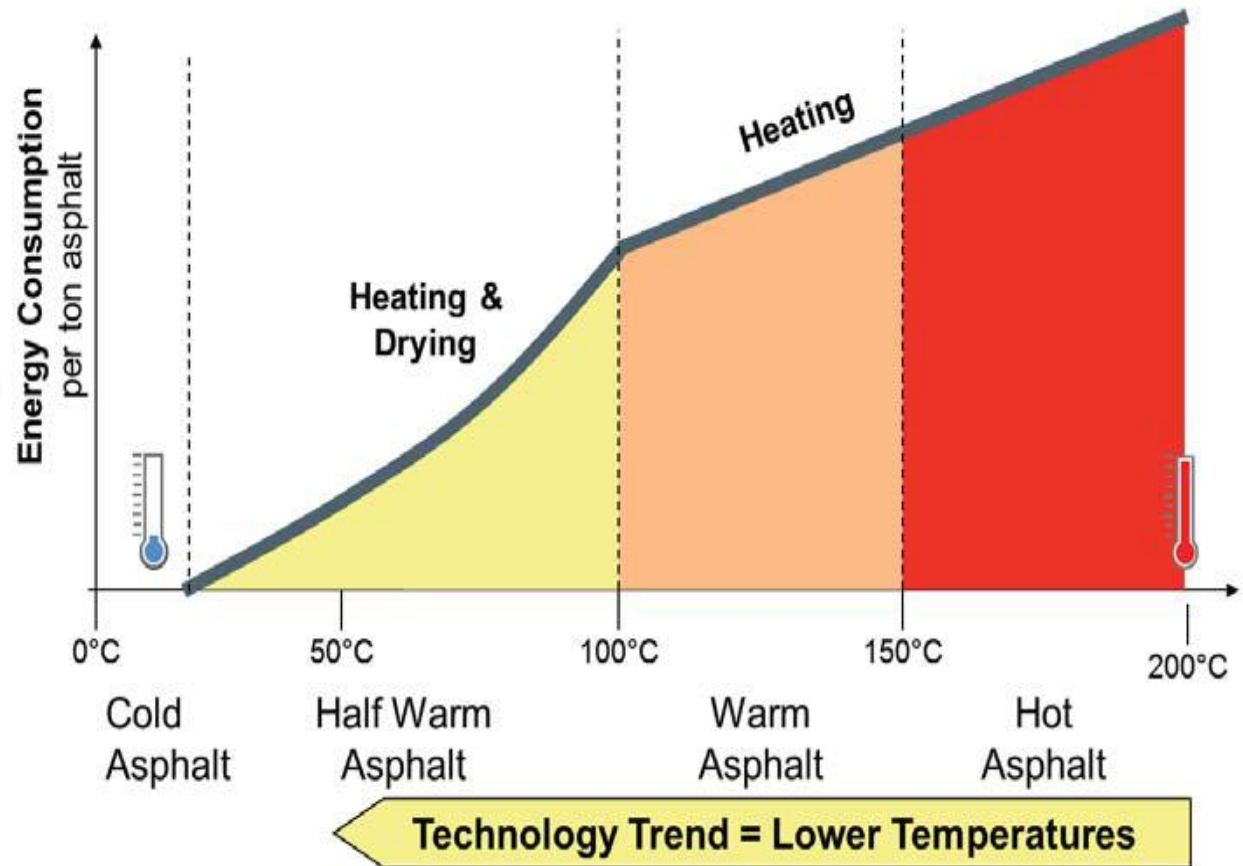
19th of May 2015, Helene Odelius, Tallinn

The use of Warm Mix Asphalt

EAPA - Position Paper



EUROPEAN ASPHALT PAVEMENT ASSOCIATION



<http://www.eapa.org> "The use of warm mix asphalt, EAPA position paper", published October 2014

Warm mix techniques used in Sweden

- ▶ KGO
- ▶ Foaming, NCC Green asphalt®
- ▶ WAM™ foam (Shell)
- ▶ Additives, e.g. Evotherm, 70, Secabase etc
- ▶ Reheating for warm mix

KGO

NCC Green
Asphalt

Bitumen for
warm mix
Nytherm

Drivers for warm mix in Sweden

- 1) Environmental
- 2) Working Environment
- 3) Cost savings
- 4) Performance
- 5) Benefits in performance
 - a. Less bitumen aging
 - b. Often thicker bitumen coating of aggregates



Environmental benefits of Warm mix

Environment

- Reduced stack emissions during asphalt production (CO₂, CO, SO₂, VOC, NO_x [1])
- Less fuel consumption



[1] Warm-Mix Asphalt: European Practice; International Technology Scanning Program, FHWA-PL-08-007, February 2008, FHWA-HPIP, U.S. (Department of Transportation, Washington, DC, USA. (www.international.fhwa.dot.gov Fax: 001 202 366 9626)

Work environment benefits of Warm mix



Work Environment

- Reduction of fuming
- Cooler conditions for the asphalt workers
- Minimizes inconvenience to the public near work sites

<http://www.eapa.org> “The use of warm mix asphalt, EAPA position paper”, published October 2014

Performance benefits of Warm mix



Performance

- Reduced aging of the binder gives improved thermal and fatigue cracking resistance
- Better workability
- Extending the construction season
- Faster cooling to ambient temperatures => earlier opening of the road
- WMA is fully compatible with the use of RAP.

<http://www.eapa.org> *“The use of warm mix asphalt, EAPA position paper”, published October 2014*



KGO



KGO

- ▶ Patented mixing sequence and procedure (Karl-Gunnar Ohlsson)
- ▶ Approximately 10 years of experience in Sweden
- ▶ Over 1 million tons of asphalt made
- ▶ The first five years the Swedish road administration gave a bonus for use of the technique
- ▶ The last three years The Swedish road administration have tendered KGO specifically for many road stretches



How does KGO work?

I

Aggregate >4mm

Binder



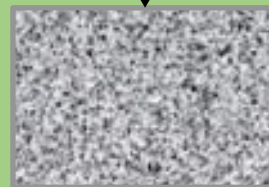
II



Fine material/filler is added with the help of sheet metal

III

Aggregate 0-4 mm



KGO can not be used in drum mixing plants only in batch mixing plants

The mixer needs to be modified for KGO (moderate investment)

The mixing sequence gives a more even mix of fine material and bitumen in the asphalt

In some plants the mixing time increases and the capacity is lowered

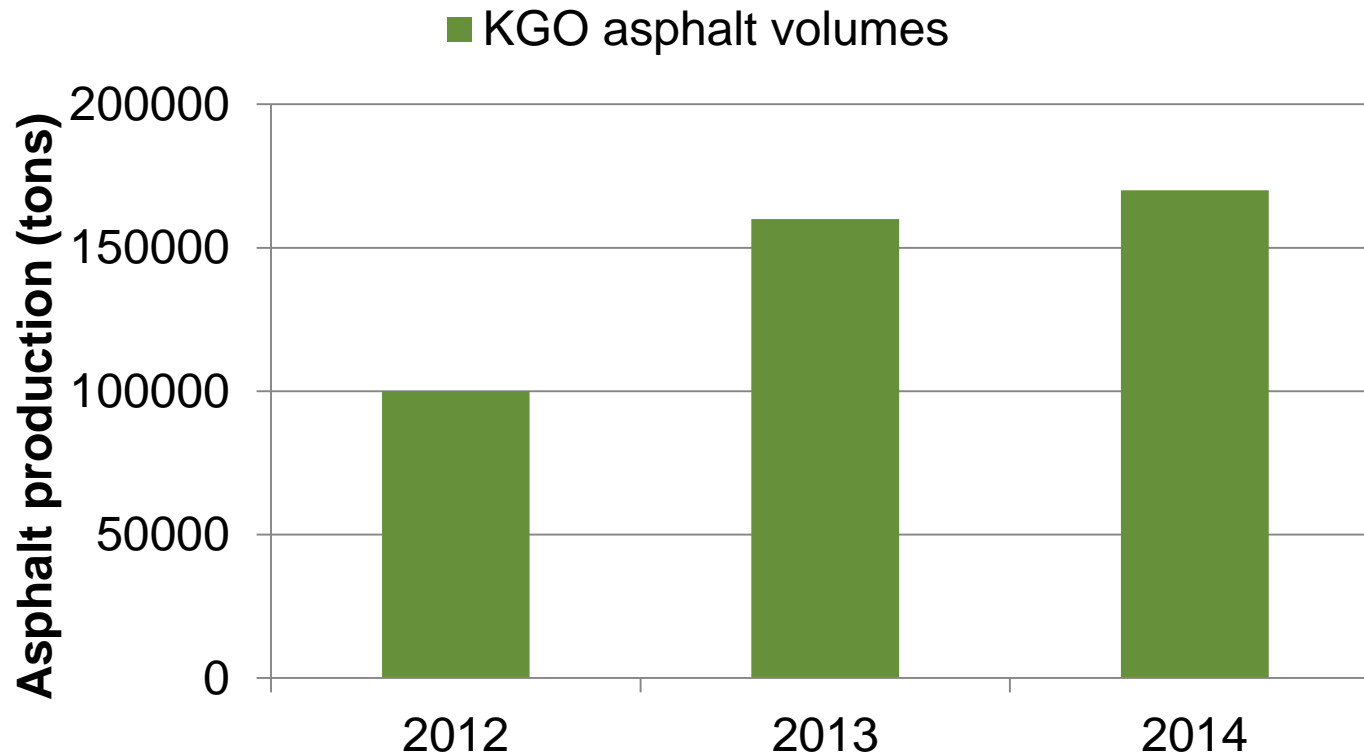
Results in a lowering of mixing temperature with 15-30 degC without changing compaction properties

KGO has been shown to.....

- ▶ Mitigate separations in the asphalt mix
- ▶ Increase the thickness of the bitumen films on the coarse aggregate
- ▶ Possibility to lower production temperature by 15-30°C with the same compacting properties
- ▶ Lower the amount of fumes and the bitumen aging
- ▶ Possibility to lower bitumen content with 0,5 percentage in the wearing course
- ▶ Good durability due to the more efficient use of the binder and more homogeneous mix
- ▶ Give mixes that is slightly heavier for hand laying

Source: The Swedish Transport Administration, Publication 2008:95

Volume development KGO



Total yearly production in Sweden is 7 million tons of asphalt



NCC Green Asphalt®



NCC Green Asphalt®

- ▶ Registered trade mark of a foaming technique used by NCC
- ▶ Production temperatures can be lowered from 160°C to 120°C
- ▶ Mitigation of heat separation
- ▶ More homogeneous mix
- ▶ Easy to compact – low void content
- ▶ Good stability
- ▶ Good adhesion properties
- ▶ More Reclaimed asphalt can be used
- ▶ No fumes and odour



NCC Green Asphalt

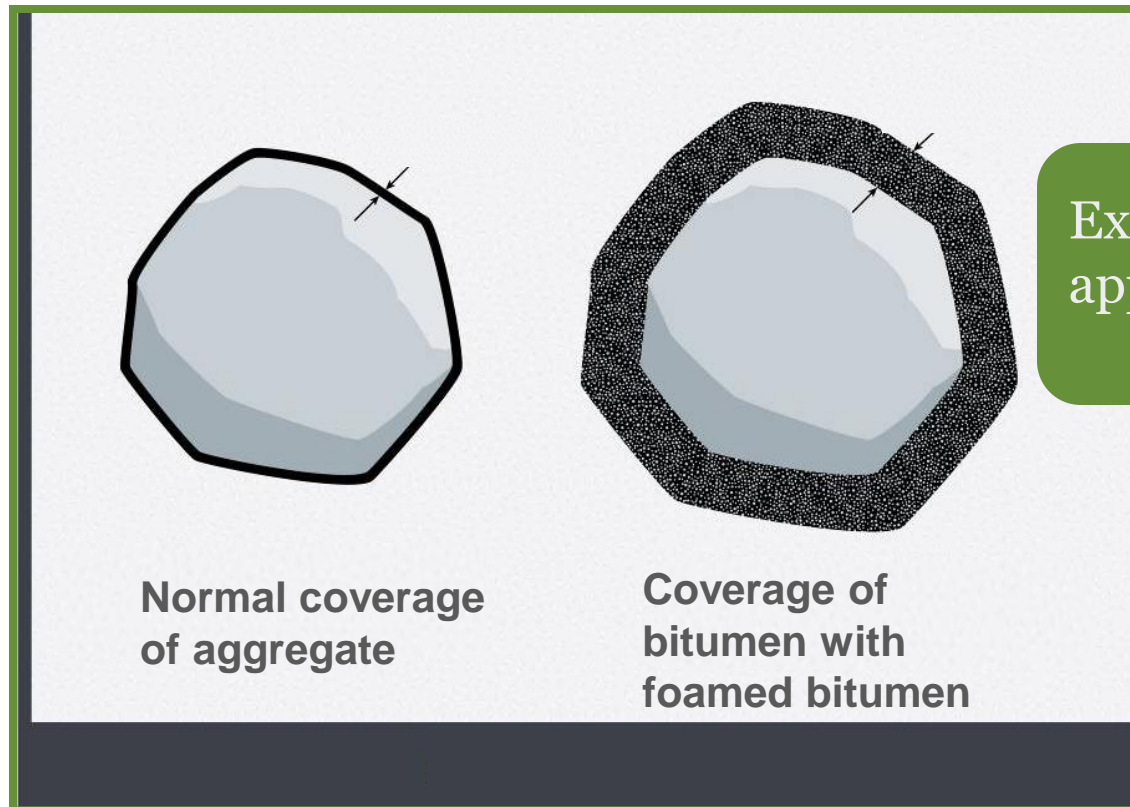
◦ Definition:

- New production process
- Production temperature $> 120^{\circ}\text{C}$
- Reduced energy consumption
- Reduced CO_2 emissions
- Reduced particle emissions
- Foamed bitumen
- 5-40% Reclaimed asphalt depending on mix
- Same performance as for hot mix
- Improved working environment

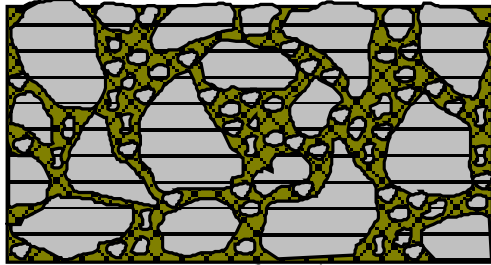


NCC Green Asphalt®

Production process - foaming

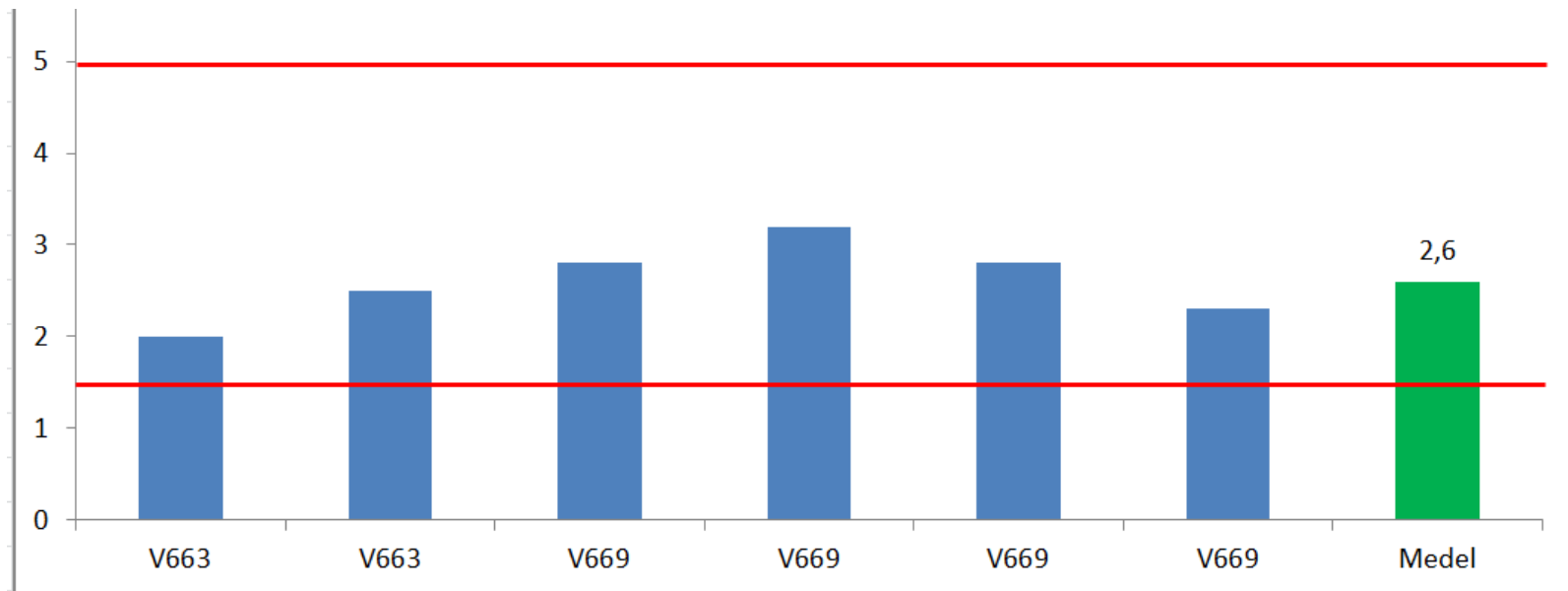


NCC Green Asphalt® ABT 16

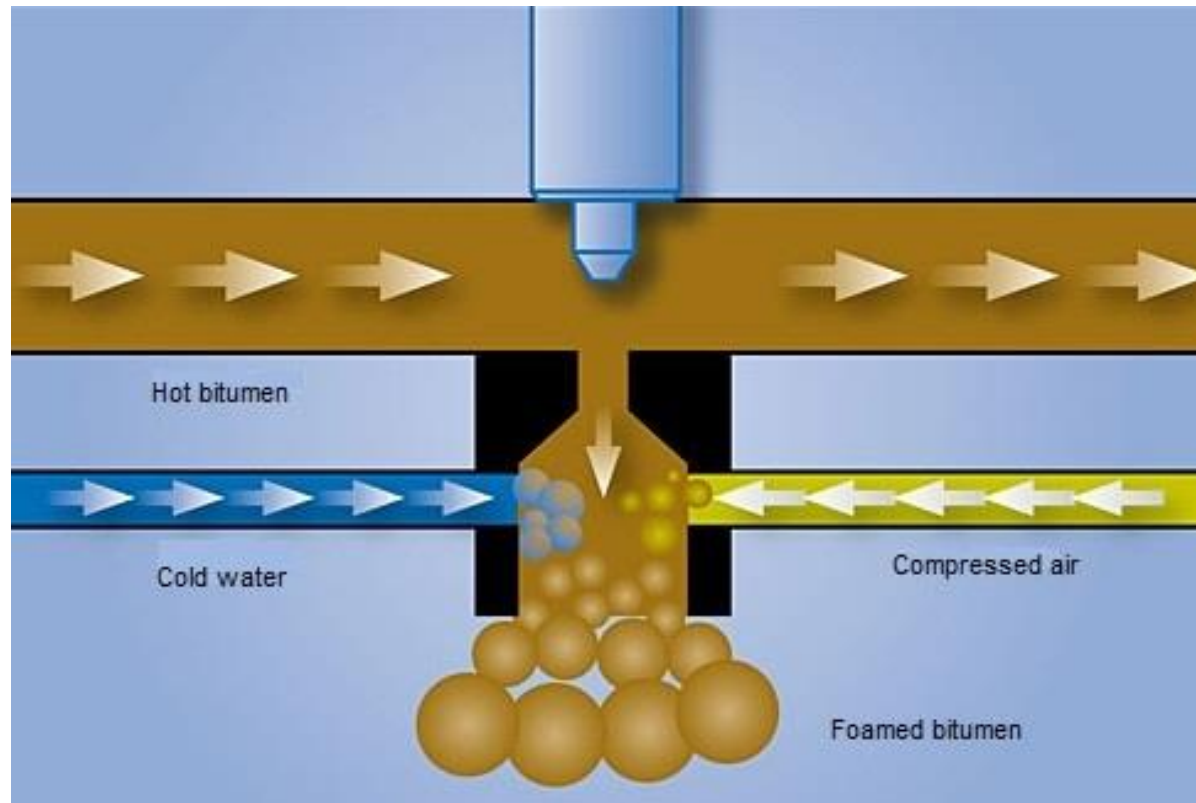


Measured void content ABT 16

Dense Asphalt Concrete



How does foaming of bitumen work?



Foaming characteristics of binders

- ▶ Foaming characteristics of bitumen binders changes with
 - ▶ Bitumen source and manufacturing
 - ▶ Added water content
 - ▶ Foaming temperature
 - ▶ PMB harder to foam than Penetration bitumen



Expansion ratio and half life

- ▶ Expansion ratio
 - ▶ The ratio of the maximum volume of the foamed bitumen to the initial volume of the liquid bitumen
 - ▶ A high expansion ratio will make coating of aggregates easier and faster
- ▶ Half life
 - ▶ The time (in seconds) needed by the foam to halve its expansion volume
 - ▶ A high half life means that the foam is more stable, also improves the coating of the aggregates



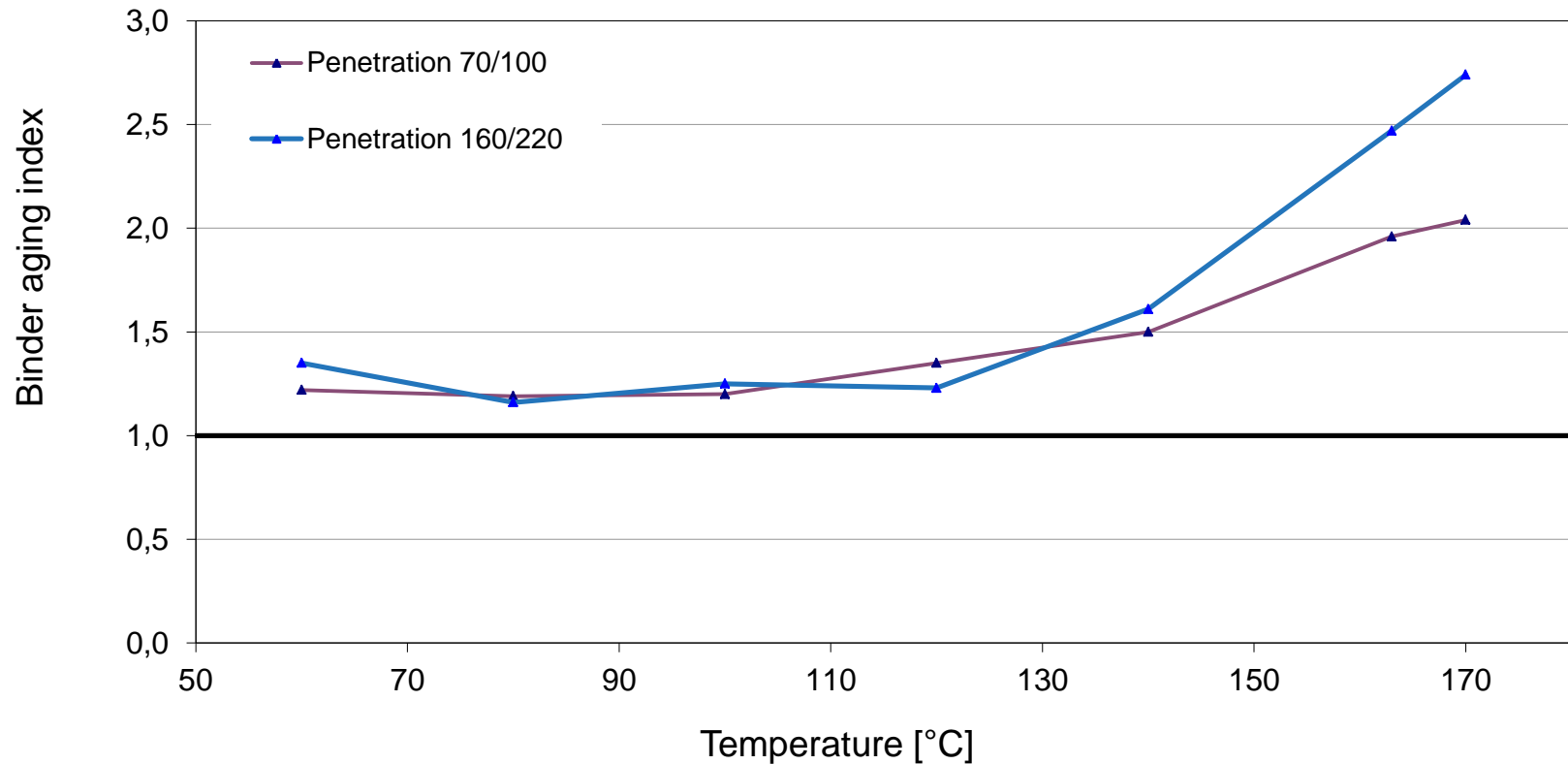
Mixing and paving with foamed bitumen

- ▶ Foamed bitumen collapses rapidly
- ▶ Workability at lower temperature remains in asphalt mix
- ▶ Water sensitivity – Adhesion agents
- ▶ Less short term aging due to the lower production temperature



*August 2009, New surface course, Årsunda, Sweden,
NCC Roads AB, Green Asphalt*

Aging of the binder



Johansson, L. 1998. *Bitumen ageing and hydrated lime*. PhD Thesis, The Royal institute of Technology, Sweden

Väg E4 Enånger-Hudiksvall 2+2 with NCC Green Asphalt®

Total stretch 24,5 km,

3km done with conventional asphalt as reference

Speed 110km/h

Traffic volume 7500 Vehicles per day

Heavy vehicles 23%

Studded tires 65%

Volymes

AG 22/32 (30%RAP)

76 000 ton

ABb16 (20%RAP)

29 000 ton

ABS11 (5%RAP)

36 000 ton



Här produceras NCC Green Asphalt®



Sverige:

- Piteå
- Skellefteå
- Umeå
- Sundsvall
- Östersund
- Växbo
- Hudiksvall
- Gävle
- Borlänge
- Uddevalla
- Örebro
- Vårby (Stockholm)
- Skälunda (Norrköping)
- Six Pack Mobilt (NCC Roads Nord)
- Göteborg (Hisings Kärra)
- Södra Sanby
- Arlanda
- Biskopstorp
- Kvidinge
- Karlstad
- Mora

Danmark:

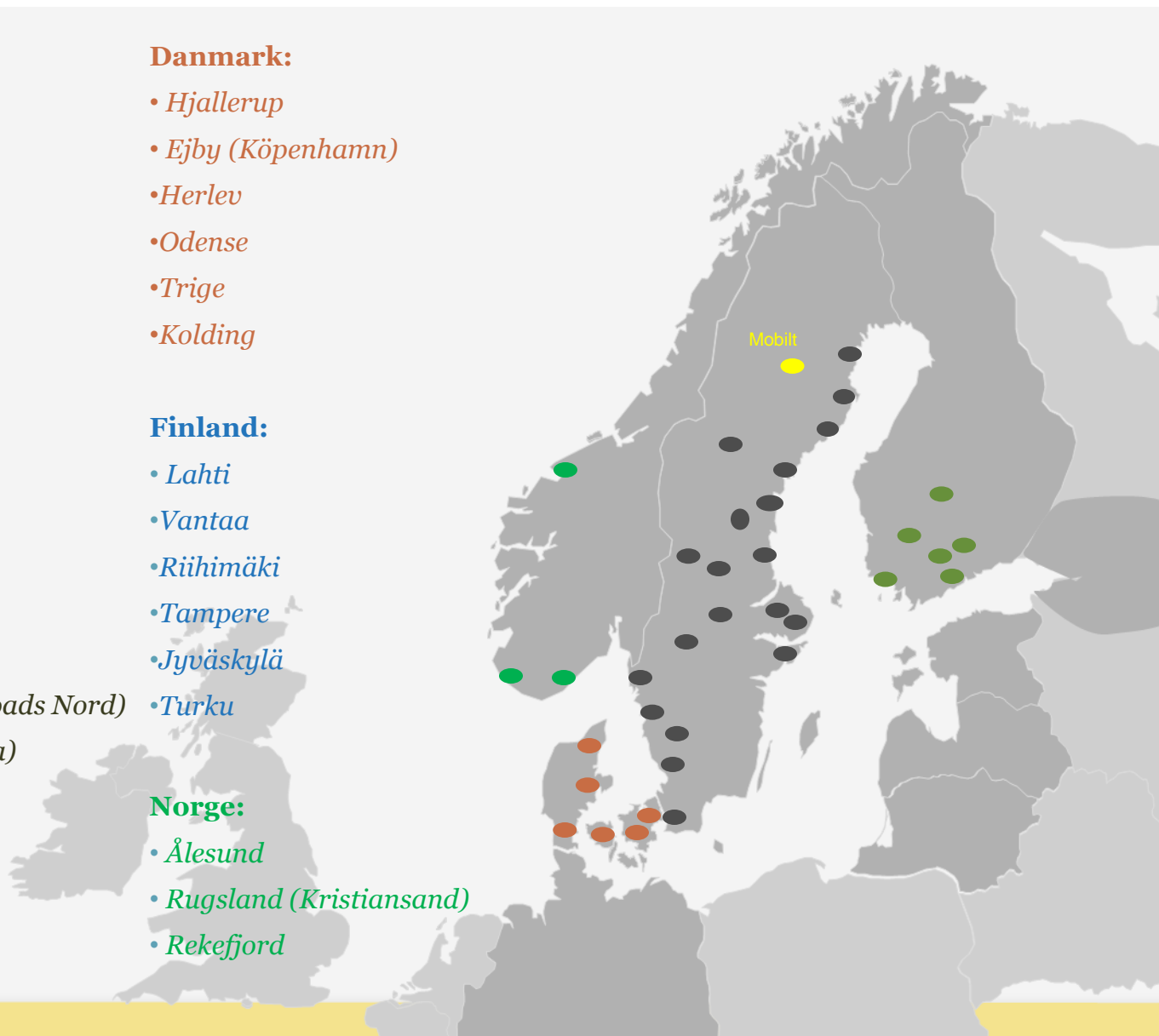
- Hjallerup
- Ejby (Köpenhamn)
- Herlev
- Odense
- Trige
- Kolding

Finland:

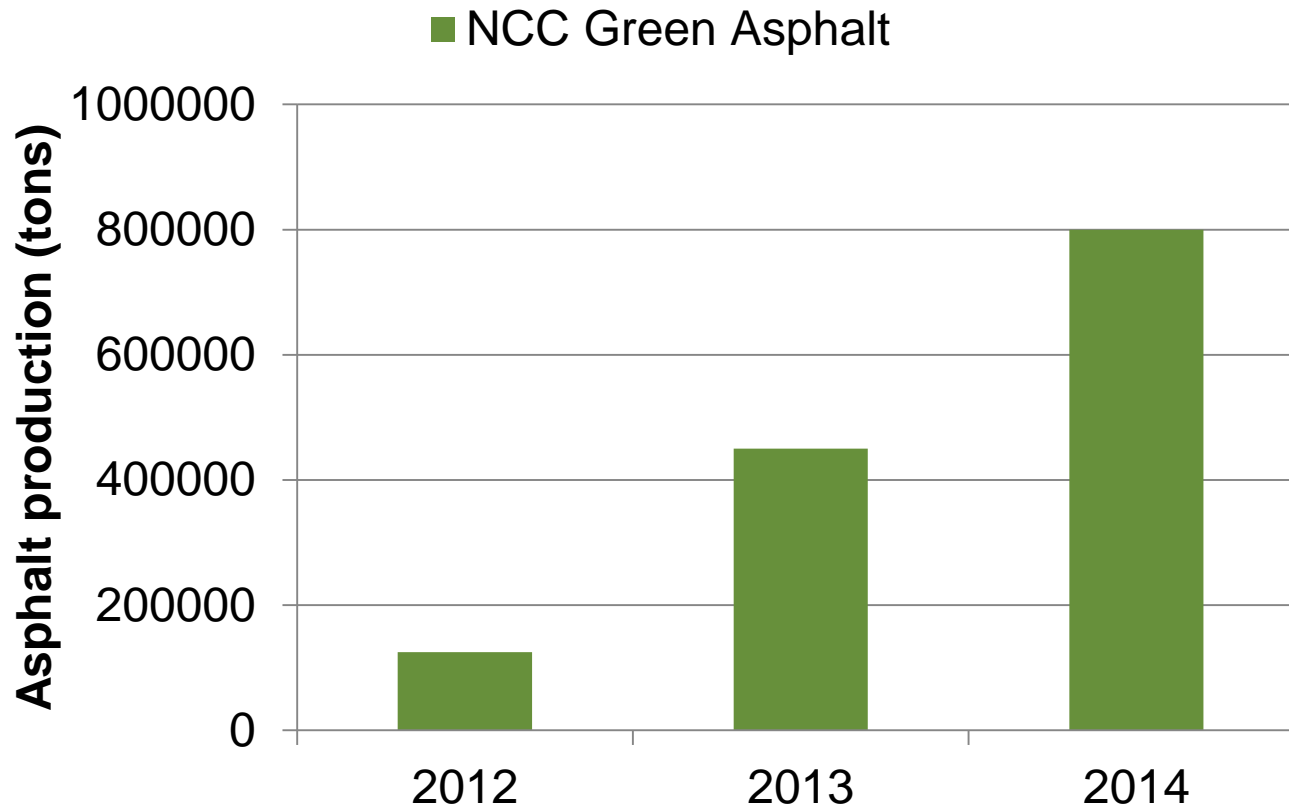
- Lahti
- Vantaa
- Riihimäki
- Tampere
- Jyväskylä
- Turku

Norge:

- Ålesund
- Rugsland (Kristiansand)
- Rekefjord



Volume development NCC Green Asphalt®



Nordic production



Warm mix bitumen - Nytherm

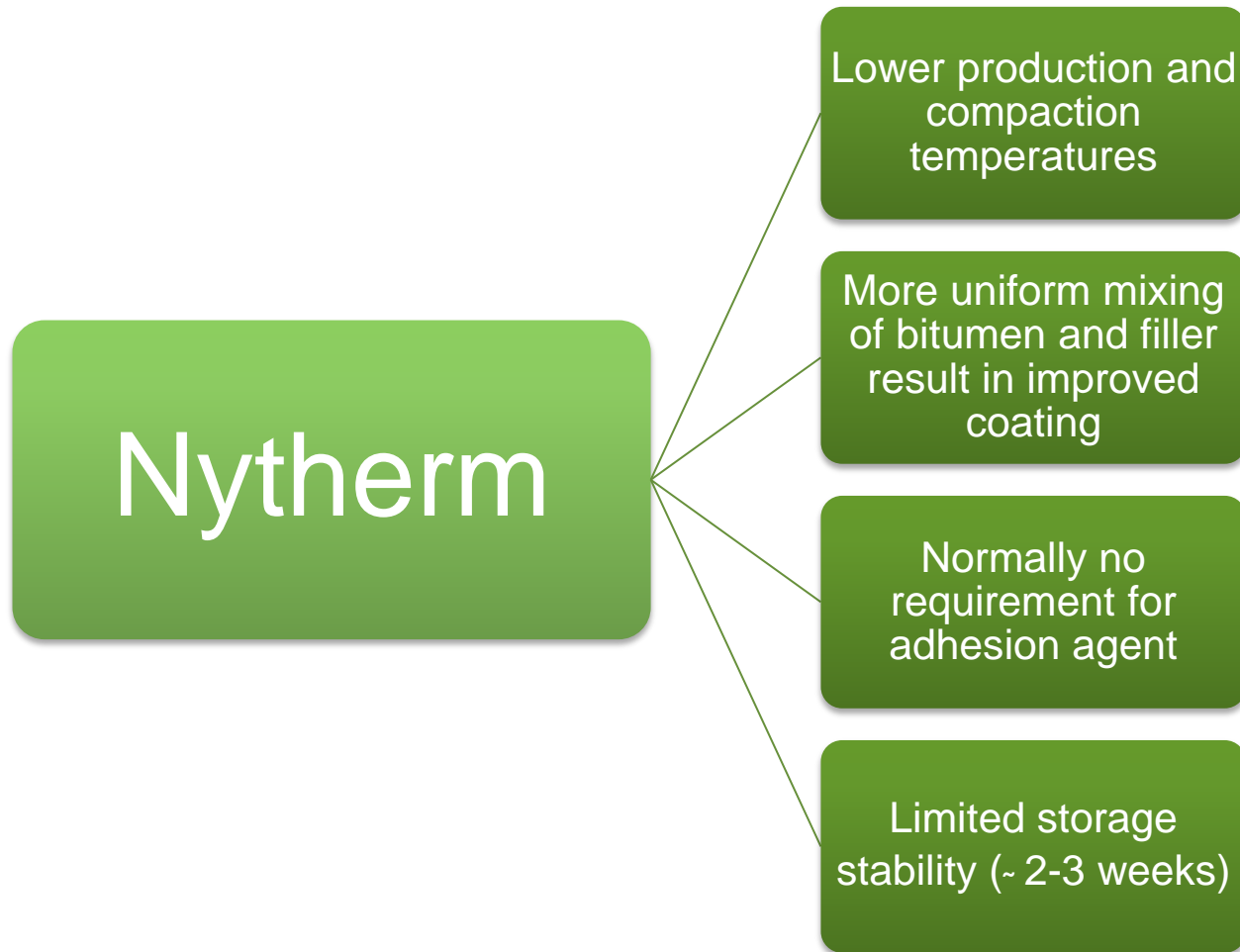


Warm mix bitumen - use of chemical additives

- Chemical additives do not change the bitumen viscosity. They work at the microscopic interface of the aggregates and the bitumen
- They regulate and reduce the frictional forces at that interface
- Additives can result in a thicker bitumen film around the aggregate
- Additives can also improve adhesion behaviour
- With warm mix additives it is possible to mix the bitumen and aggregates and to compact the mixture at a lower temperature

Ready made bitumen for warm mix - Nytherm





Lowering of temperatures

With Nytherm mixing, paving and compaction can be made at 20-30°C lower temperature than for conventional asphalt

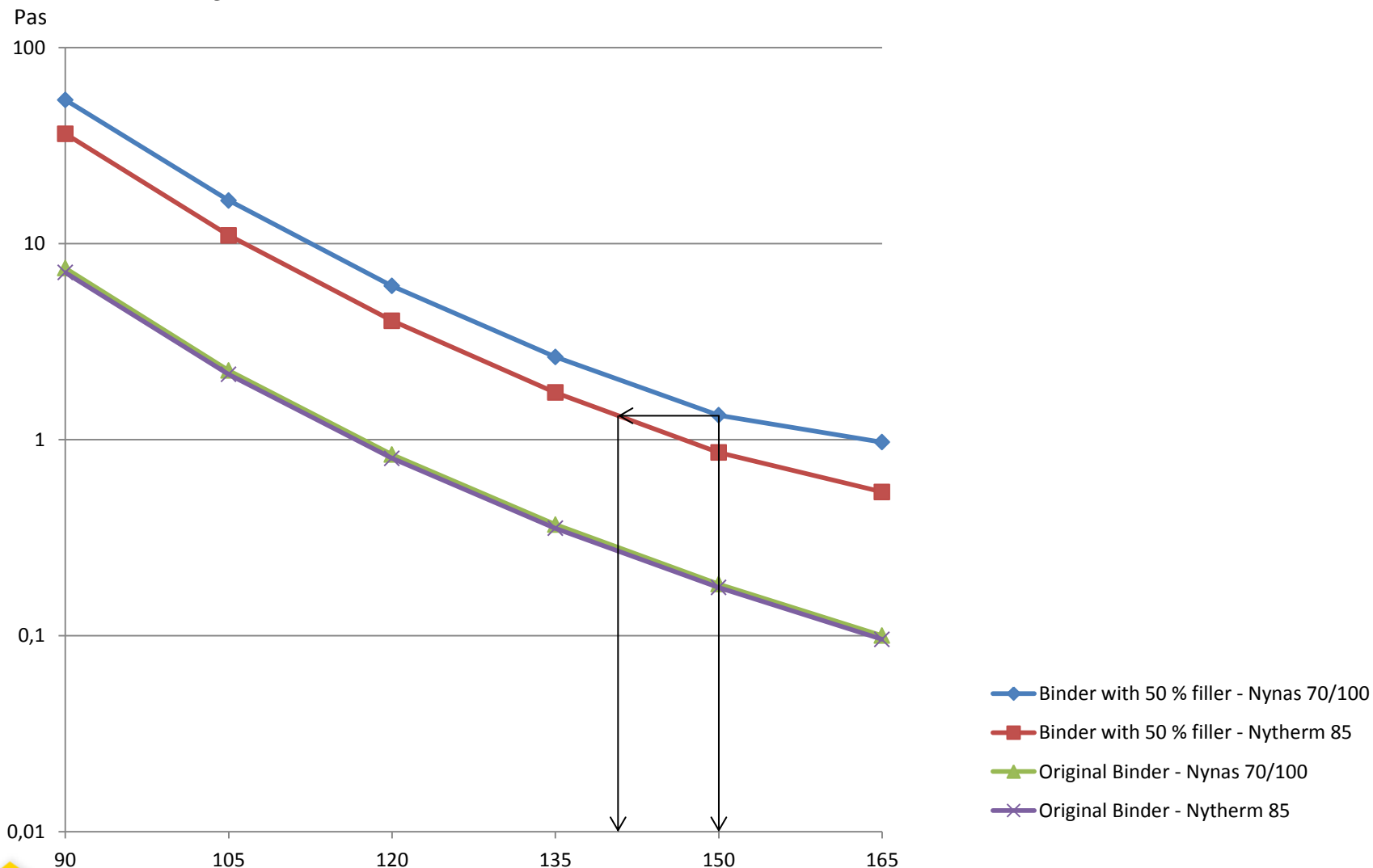


SMA 11, temperature 150°C



SMA 11, temperature 130°C

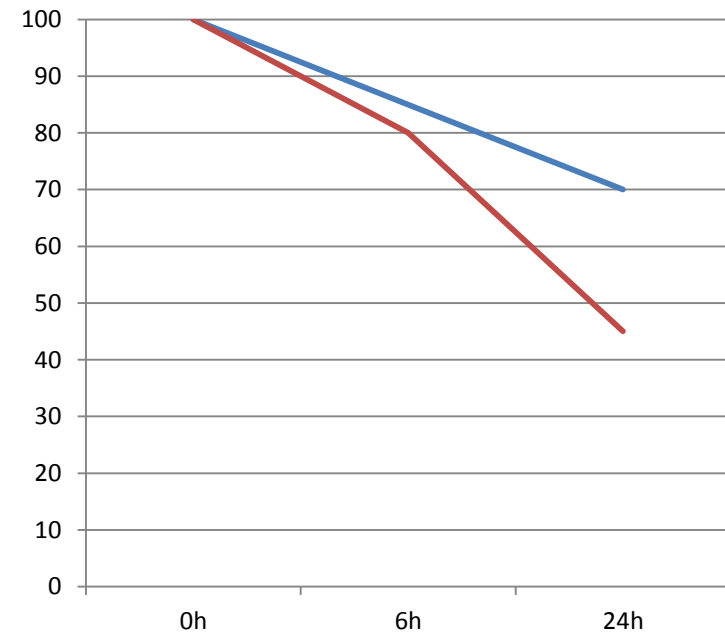
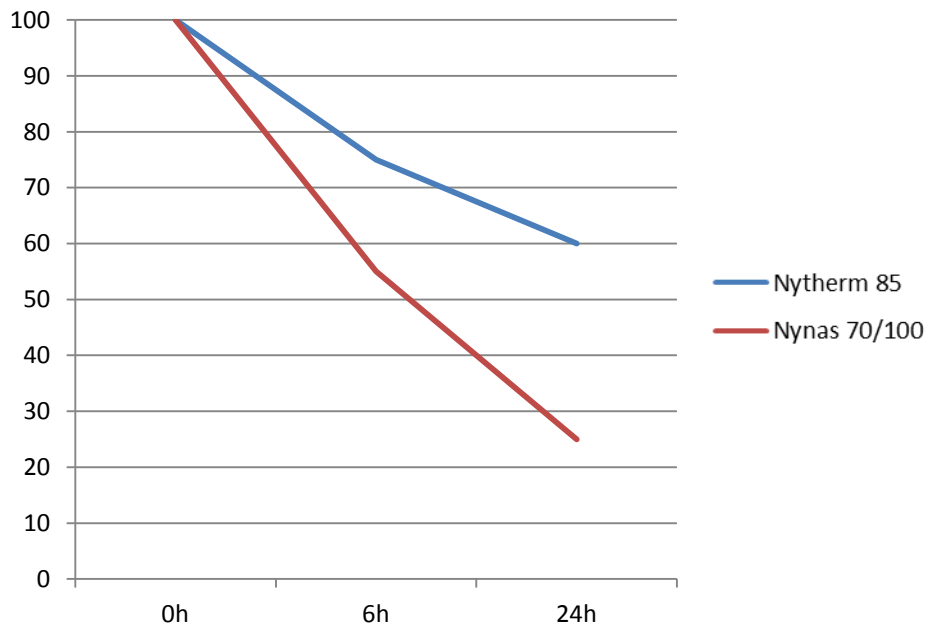
Viscosity measurement - DSR



Adhesion

With Nytherm there is normally no need for additional adhesion agent

Rolling bottle test



Vändskak (turning shaker)



Nynas 70/100

21,9 g* (lowest value 19,4 g)

Nytherm 85

15,9 g* (highest value 16,4 g)

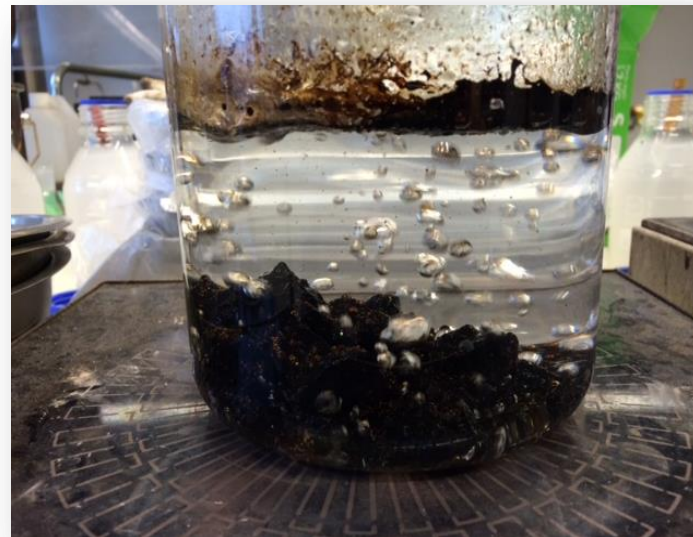
* Weight loss, mean of six slabs

Nytherm can be stored at least two weeks

- ▶ Boiling test can be done to check effect
- ▶ Blend 4% bitumen with 300 gram 11/16 aggregate
- ▶ Condition the blend for 30 minutes at 160°C
- ▶ Boil in salty water for 60 minutes



Nynas 70/100



Nytherm 85

Nytherm

For virgin aggregate

Nytherm 85

Nytherm 125

Nytherm 190

Nytherm RX

For maximum 30% RAP

Nytherm RX 85

Nytherm RX 125

Nytherm RX 190

1 640 ton
bitumen
delivered
in Sweden
2014

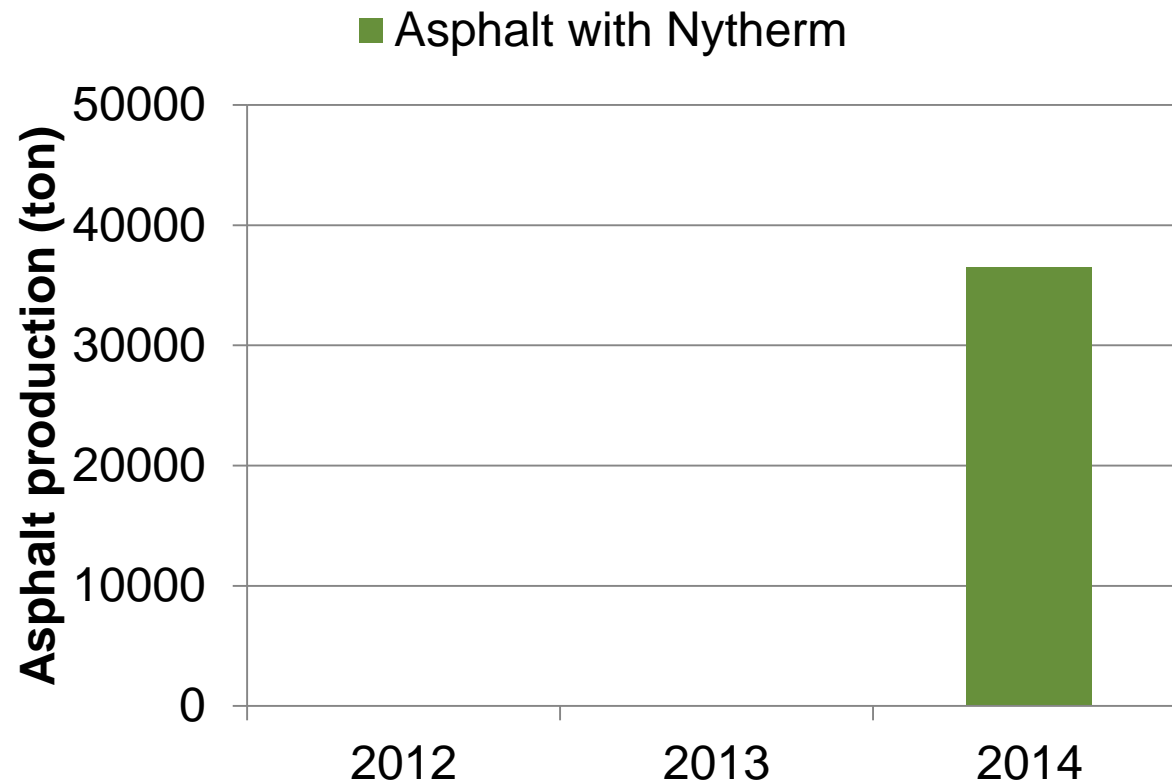
Recommendation before use

REDUCE
TEMPERATURE



- ▶ Conduct a new mix design with the chosen binder to
 - ▶ Secure stability
 - ▶ Secure adhesion properties
 - ▶ Confirm optimum binder content

Volume development asphalt with Nytherm





Summary



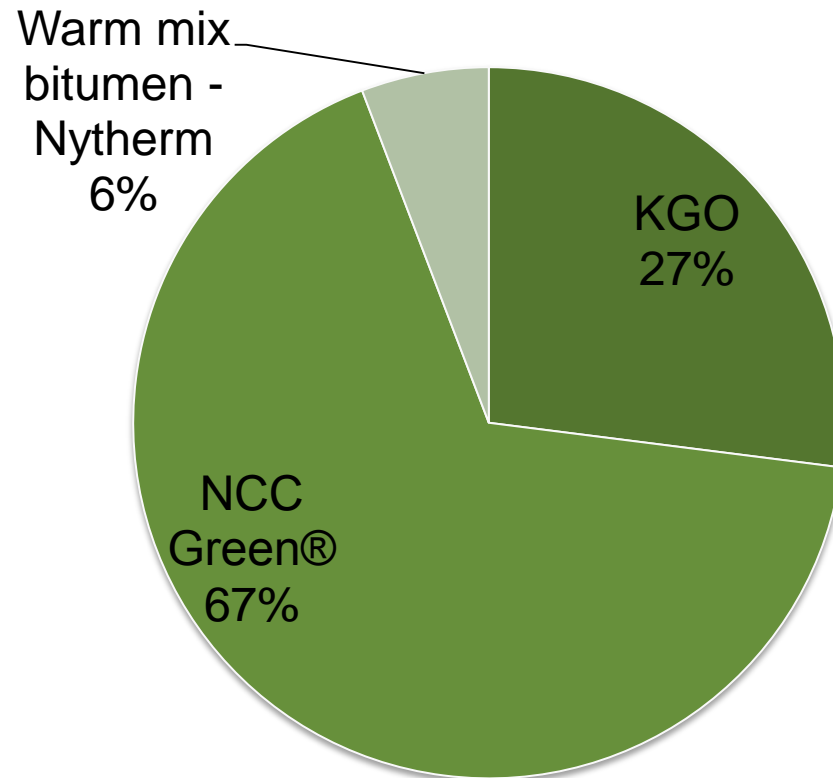
Experience show that
warm mix asphalt give
equal or better
performance as hot mix

Reduced environmental
impact

Improved working
environment

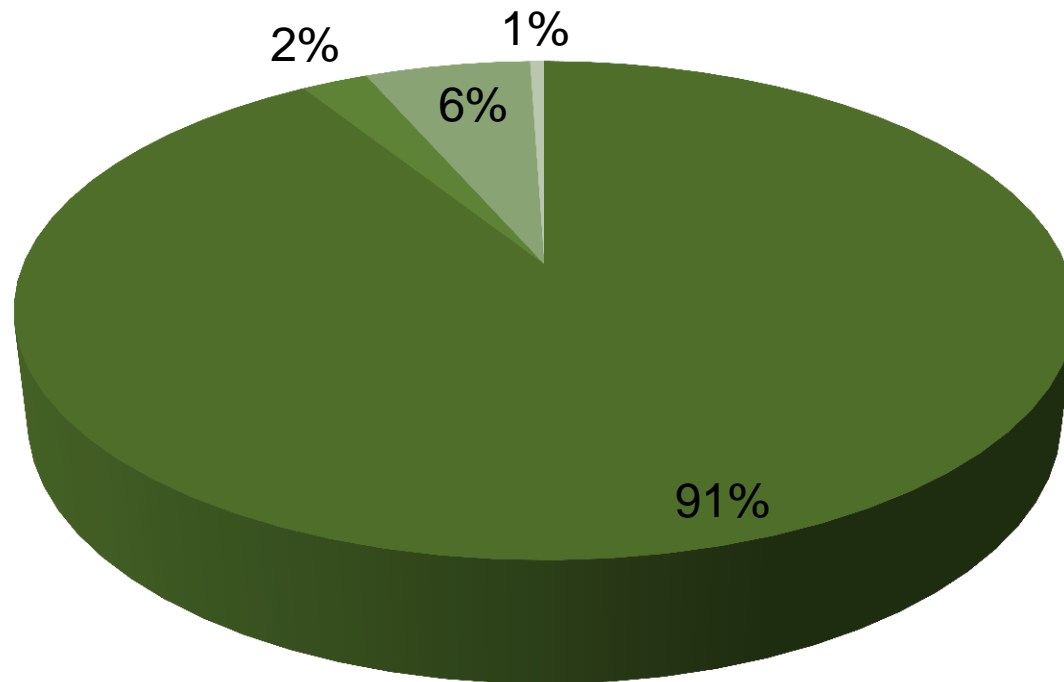
Clear trend of increasing warm mix usage in Sweden

Warm mix techniques in Sweden 2014



Asphalt mix in Sweden 2014

■ Hot mix ■ KGO ■ NCC Green® ■ Warm mix bitumen - Nytherm



RESOLUTION

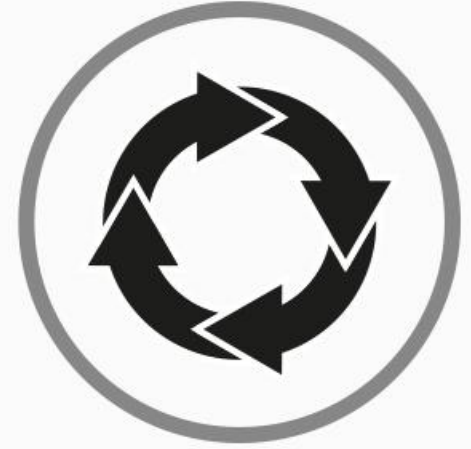
THE ROAD TO SUSTAINABLE PERFORMANCE



REDUCE
TEMPERATURE



REINFORCE
DURABILITY



REUSE
MATERIAL

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