How amine surfactants work as adhesion promoters

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2019.10.15

Agenda

Legislations and drivers for improving adhesion

What is the problem and why?

What is the solution and how it works?

Asphalt applications using Adhesion Promoters

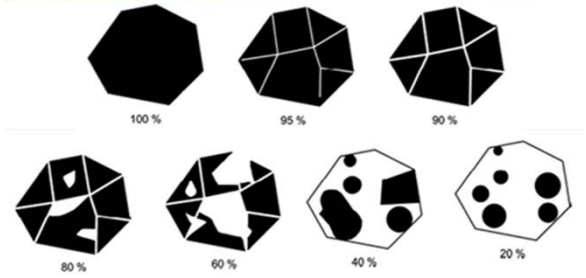
Test methods

Legislations and drivers for improving adhesion

National

De nationella kraven i de Norske Retningslinjer asfalt 2019 säger:

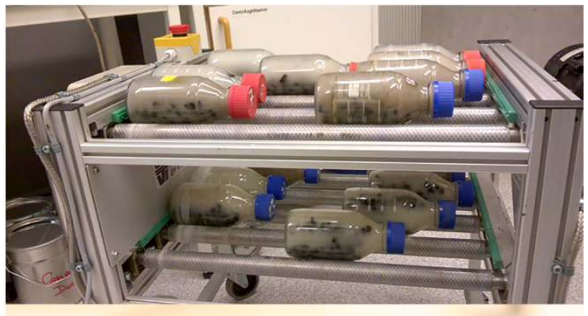
att täckningen ska vara > 20 % efter 72 timmars rullning med ett stenmaterial som ger 0 % täckning efter 24 timmars rullning utan vidhäftningsmedel.

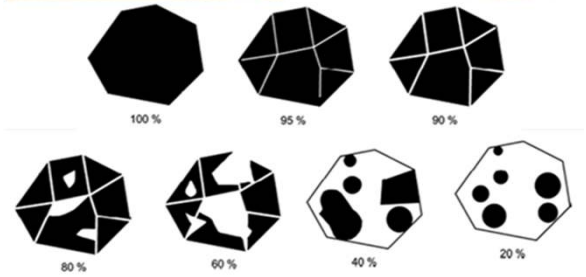


Example of regional

Från region mitt i Norge kräver följande:

c) Ved bruk av amin som vedheftingsmiddel skal det til varme masser tilsettes tilstrekkelig mengde og minimum 0,3 % amin regnet av bindemiddelet. Minimum dekningsgrad etter rulleflaskemetoden NS-EN 12697-11 skal være 40 % etter 48 timer.





Drivers for improving adhesion

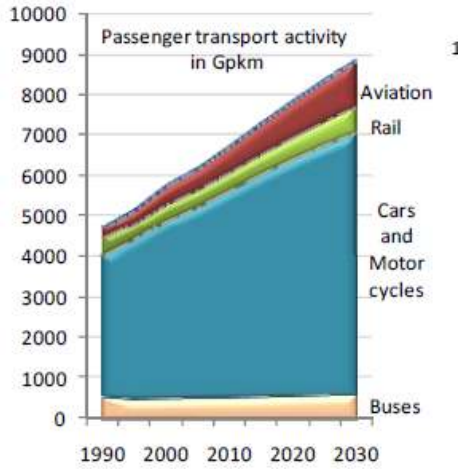
Growth in passenger and goods transport

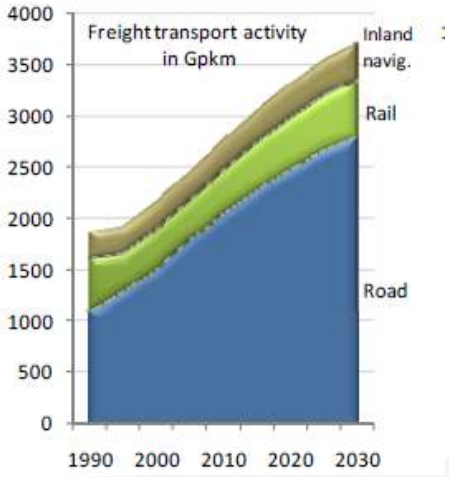
Increased focus on durability of Asphalt Pavement due to demand for extended warranty times and Long Term Contracts

Varying aggregate and bitumen quality

Limited funds for road construction/maintenance

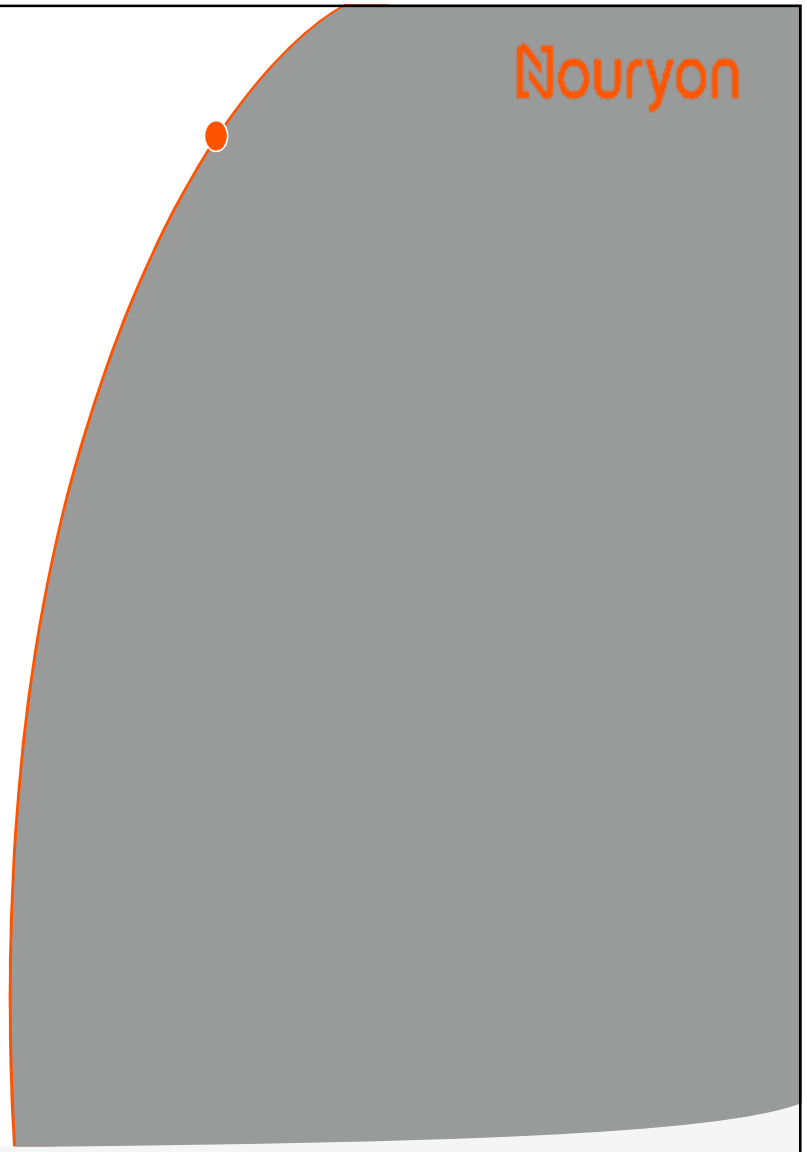
Environmental impact, paving operations consume a lot of energy and create emissions





Source; European energy and transport

What is the problem and why?



Symptoms of poor adhesion

Loss of chippings from surface – ravelling
Cracking and Potholing
Deterioration of running surface

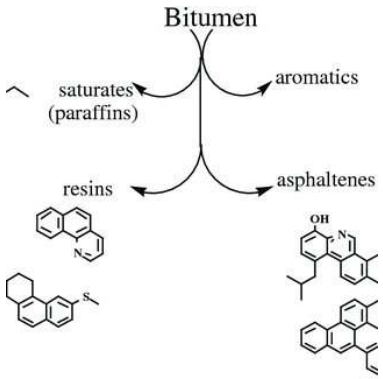
Symptoms of poor adhesion Drilled Cores…

Without adhesion promoter

With 0,3% Wetfix BE adhesion promoter after 17 years

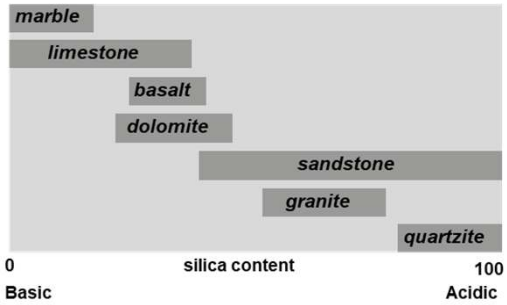
Why

Bitumen is a hydrophobic or “oily” substance



Aggregate surfaces are hydrophilic

Aggregate surfaces prefer to be in contact with water rather than bitumen



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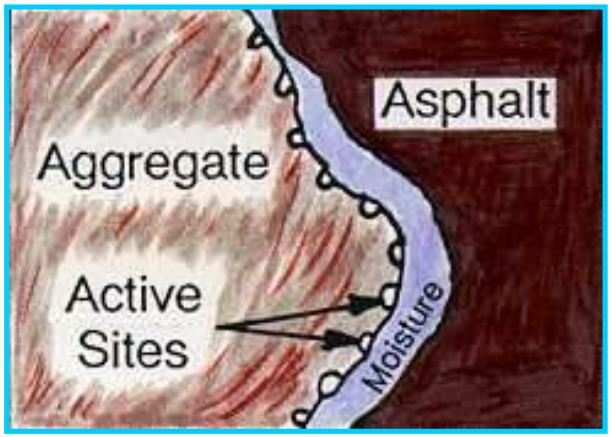
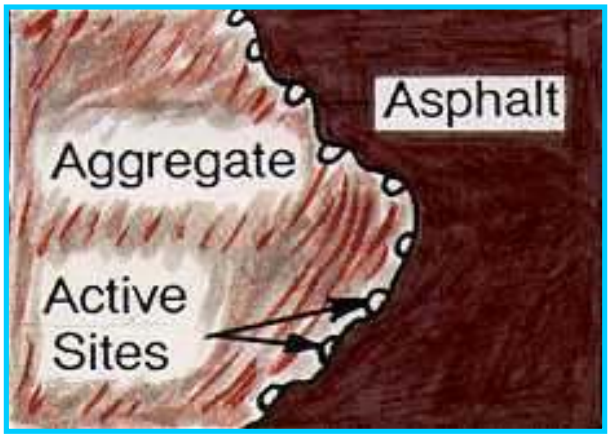
Effect of water

Coating without adhesion promoter

Coating without AP - moist aggregate



Coating without chemical bonding - clean aggregate



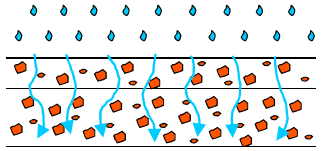
The effect of water

Bitumen cannot displace moisture from a surface and so will not adhere to wet aggregates

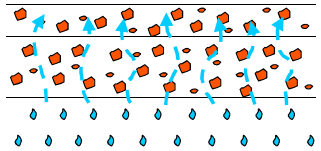
Moisture in Asphalt

Asphalt may seem like a fairly waterproof material…
…but water *can* enter the voids through various means

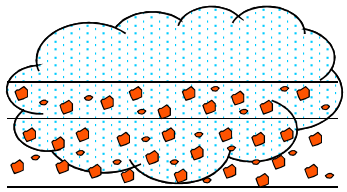
Percolation, Permeation
Surface water can penetrate asphalt



Capillary action
Water from sub-grade can rise up through asphalt



Water vapour
Moisture in the air can enter voids in asphalt and condense



Pumping action of traffic accelerates passage of water

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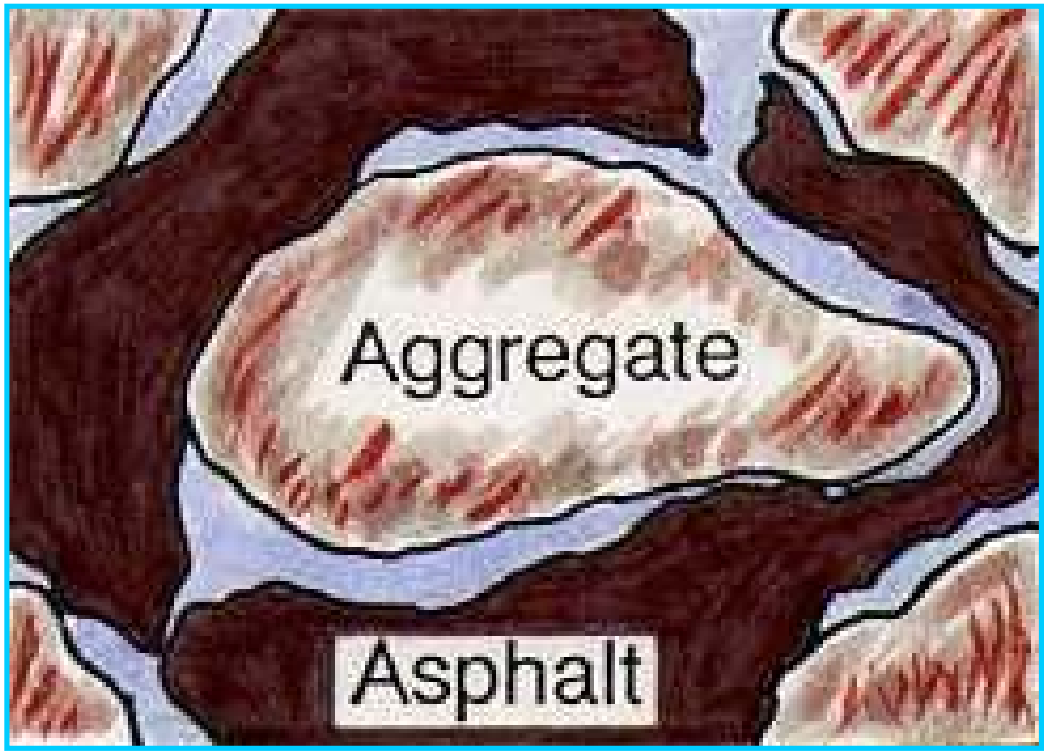
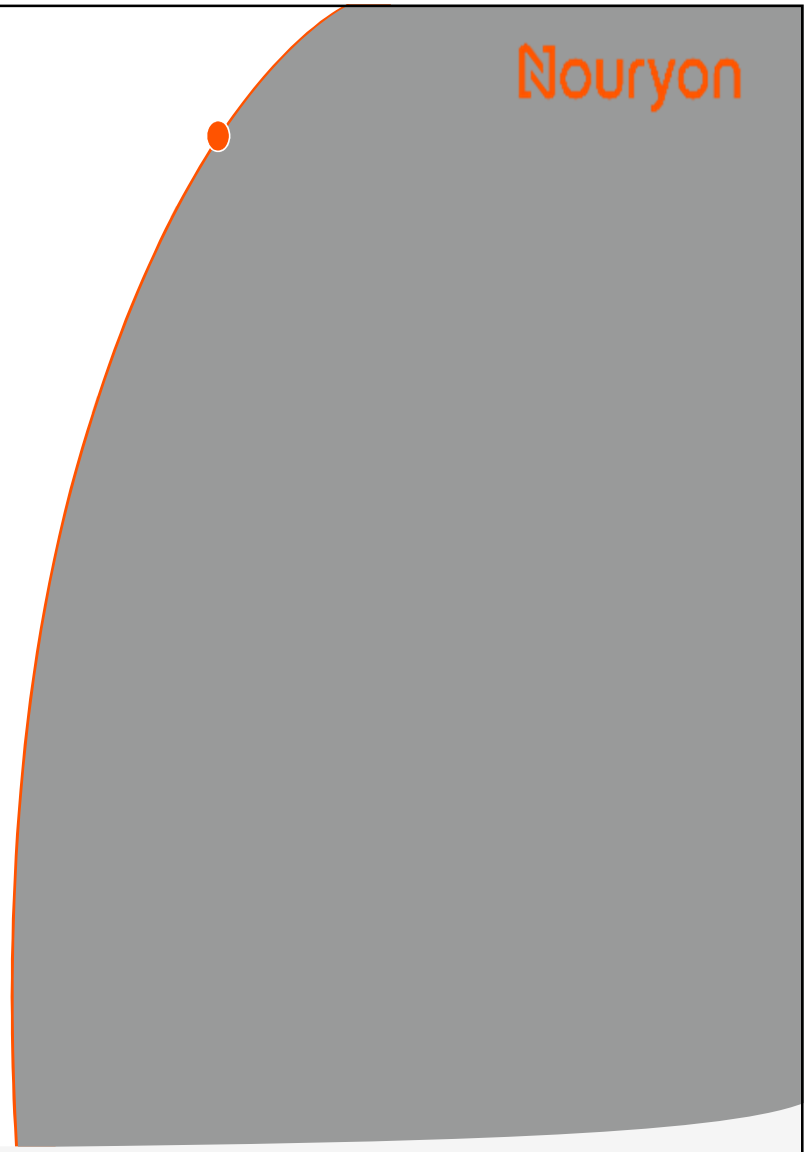
Loss of Adhesion



What is the solution and how does it work?



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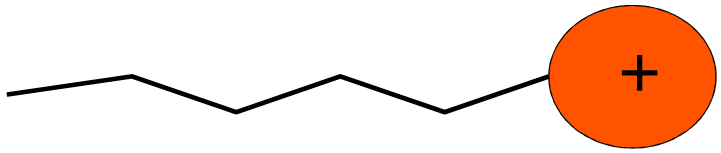
Cationic adhesion promoters

Cationic adhesion promoters are fatty amine, amidoamine or imidazoline surfactants (surface active agents)



Hydrophobic tail
Fatty alkyl carbon chain

Hydrophilic (Cationic) head group
“Amine”

Surfactants go to the interphase between hydrophobic (oil/bitumen) and hydrophilic (water/aggregate)

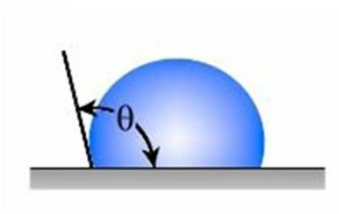
Adhesion promoter effect

Active adhesion

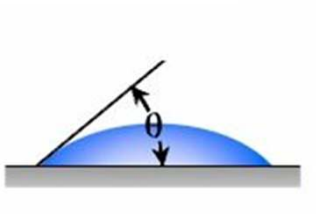
Aggregates are normally hydrophilic

Under normal circumstances, aggregates have a higher affinity for water than on oily substance such as bitumen

Active adhesion promoters decrease the contact angle between bitumen and aggregate allowing the bitumen to coat the aggregate – even in the presence of water



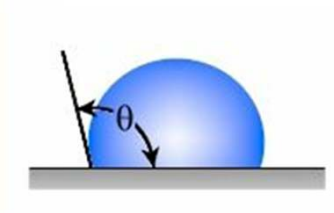
Bitumen droplet on aggregate surface



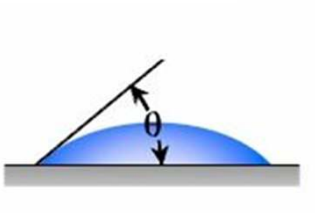
Bitumen droplet on aggregate surface with adhesion promoter

Wetting of bitumen to aggregate

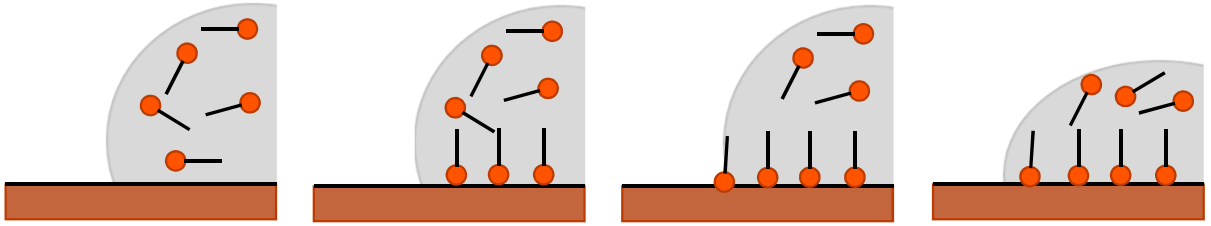
Adhesion promoters decrease the contact angle between bitumen and aggregate allowing the bitumen to coat the aggregate – even in the presence of water



Bitumen droplet on aggregate surface



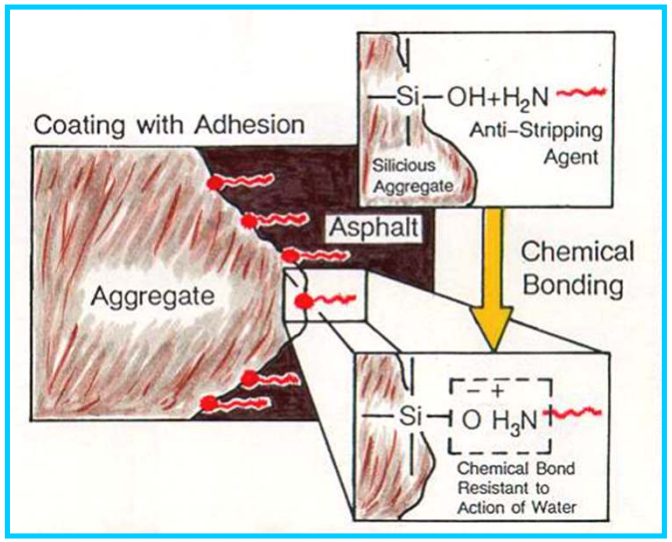
Bitumen droplet on aggregate surface with adhesion promoter



Adhesion promoter effect

Passive adhesion
Over time, water can displace bitumen from an aggregate surface – this is called stripping

Passive Adhesion Promoters
strengthen the bond between bitumen and aggregate preventing stripping



In the image: Chemical bonding is actually hydrogen bonding (the sharing of the hydrogen atom between the surfactant and the silica surface)

Active adhesion at work

Asphalt applications using Adhesion Promoters

Hot and Warm Mix
(0,2 – 0,5 % passive AP's or WMA)

Soft bitumen mix 50-120°C (0,6-1,2 % active AP's)

Stabilization with foamed bitumen (0,6-1,2 % active AP's)

Surface dressing with cut back or hot sprayed bitumen (0,5-1,2 % active AP's)

Penetration macadam (0,5-1,2 % active AP's)

Test methods

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Passive adhesion
- Rolling bottle, SS-EN 12697-11
- Water sensitivity, SS-EN 12697-12
  - ITSR / ITSM
- Static water immersion test, CEN
- Wheel track under water, USA

Active adhesion
- Rolling bottle, wet aggregate
- Static water immersion test, wet aggregate
- Immersion tray test
- Wet mixing test, VTI
- Vialit plate test




Why use Adhesion Promoters?

Legislation

Adhesion to dry and wet aggregates

Prolong the life of asphalt pavements

Allows a wider selection of aggregates

Minimal additional cost

Thank you

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