Swedish experience of modified binders and asphalt mixtures

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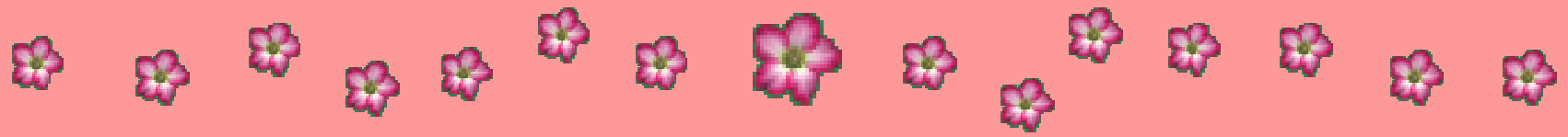
KTH VETENSKAP OCH KONST

TH Architecture and

Bitumen modifiers

- Anti-stripping additives (amines, hydrated lime, cement)
- Polymers (SBS)
- Fibers



- Crumb-rubber
- Wax

PMB Arlanda Runway 3

SHRP Superpave PG 64-28 + EN:

- **Density** at 25°C
  Softening point (R & B)
  Penetration at 25°C

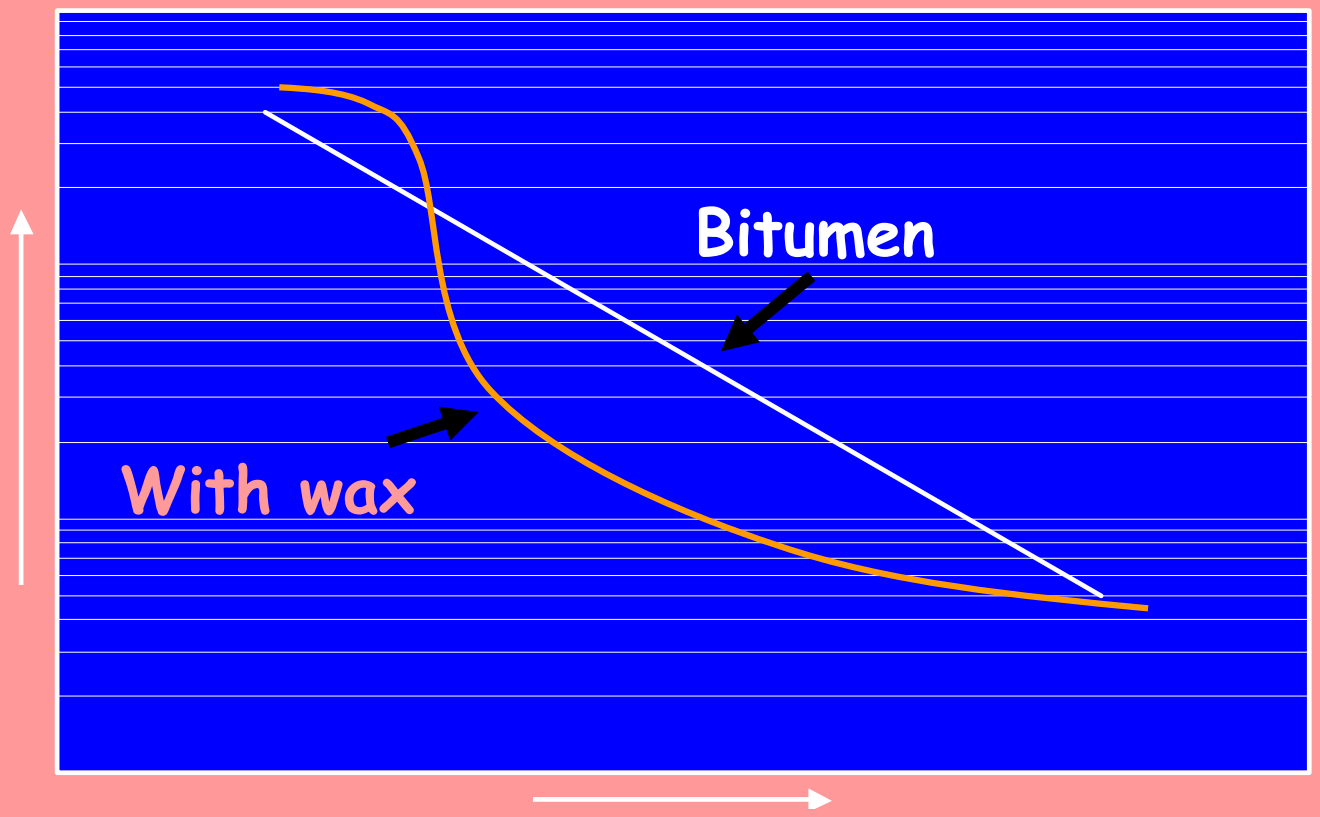
- **Elastic recovery** 70-90 % (abs. value) at 10°C
- **Storage stability** after 72 h at 180°C

- **Resistance to runway de-icing chemicals**

Swedish project about wax additive in polymer modified bitumen for mastic asphalt

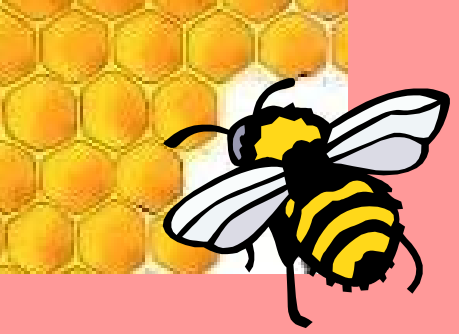
- Purpose: to make the asphalt mastic product normally used today for Swedish bridge decks, parking decks and terraces more environment friendly and easier to handle by adding a suitable wax to the pmb.

Influence of wax additive at higher temperatures



Content of presentation

- Natural wax in bitumen
- Wax as additive in bitumen
- Wax additive in polymer modified bitumen for mastic asphalt – A Swedish research project

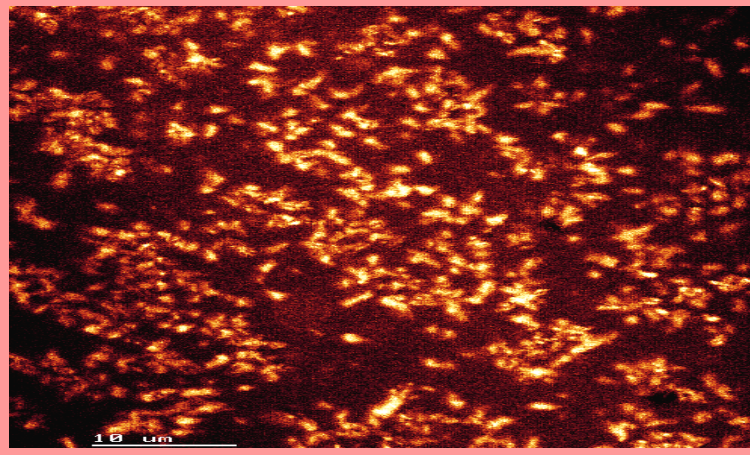


What is wax?

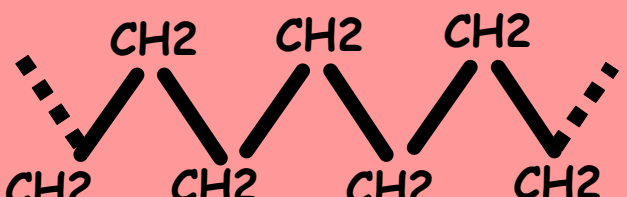
- Wax (beeswax)
- Wax-like solids and liquids (components)
- Synthetic compounds (waxy character)
- Generic term for paraffinic crystallizing material with melting point higher than ~ 25°C in petroleum products

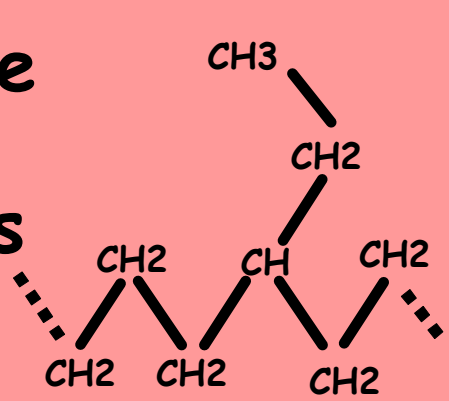
Bitumen wax categories

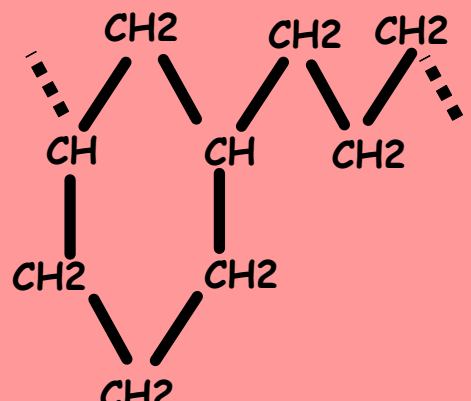
- Macrocrystalline, microcrystalline, part crystalline/amorphous wax



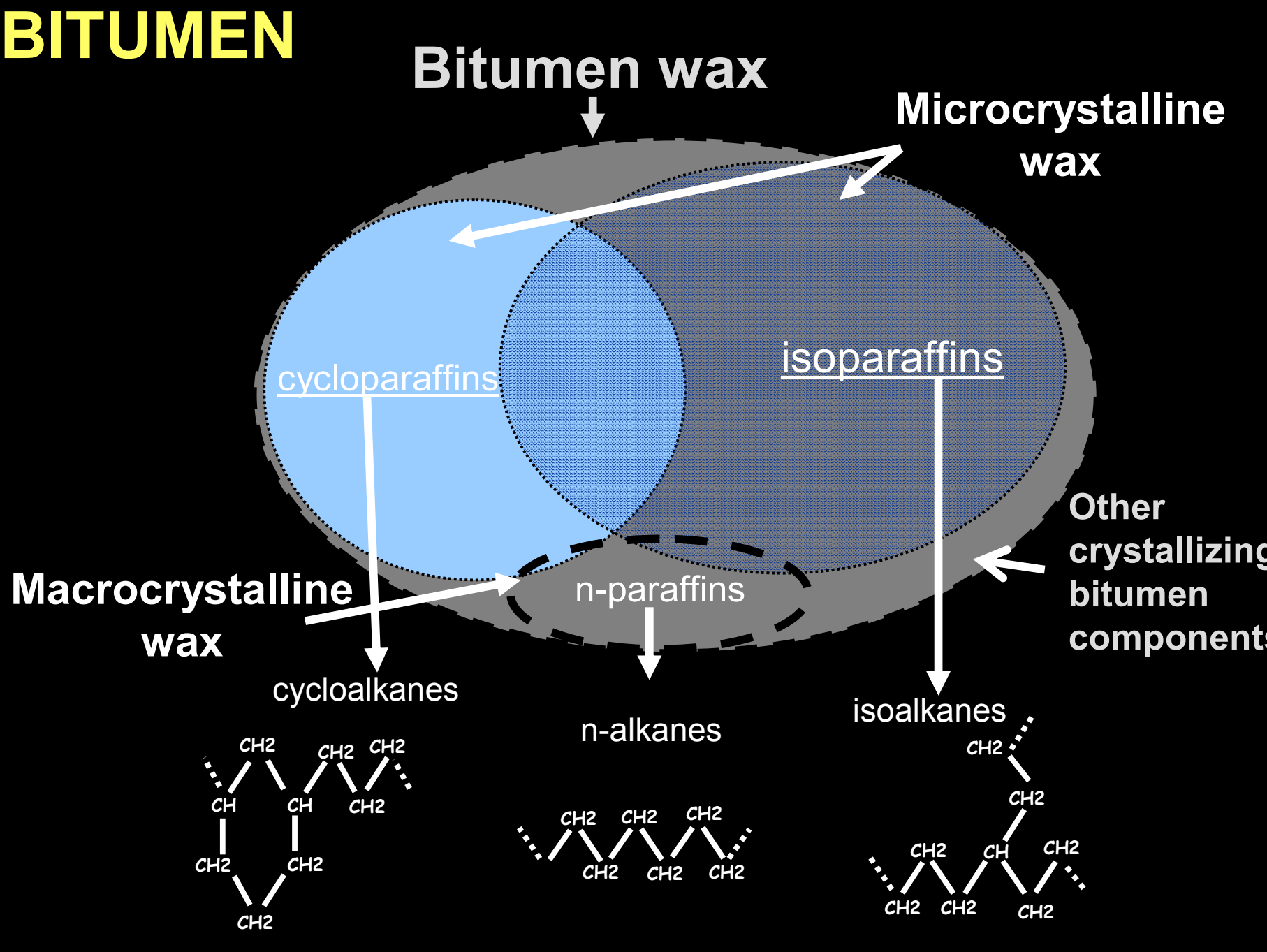
- The wax melting point increases with paraffin chain length and decreases with the amounts of branches and rings







BITUMEN


Bitumen wax
Microcrystalline wax
cycloparaffins
isoparaffins
Other crystallizing bitumen components
Macrocrystalline wax
n-paraffins
cycloalkanes
n-alkanes
isoalkanes
CH2
CH
CH2
CH2
CH2
CH2
CH2
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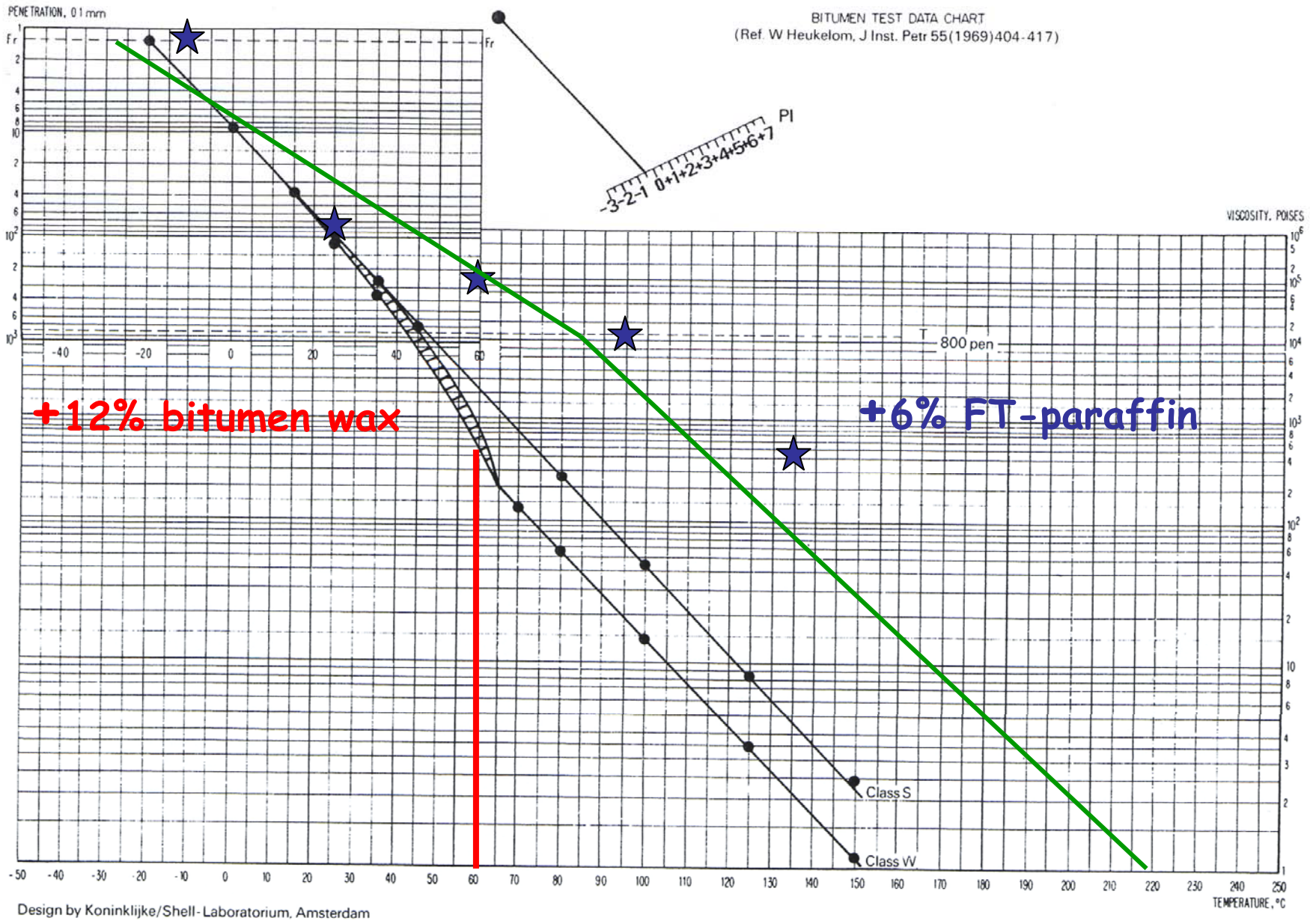


Design by Koninklijke/Shell-Laboratorium, Amsterdam

Effects of wax are influenced by:

Bitumen - chemical composition and rheological properties;

Wax – amount, chemical composition and crystalline structure - linked to crystallinity and melting properties;

Decisive for the effect of wax is the **temperature range of application**.

Flow improvers (viscosity lowering products)

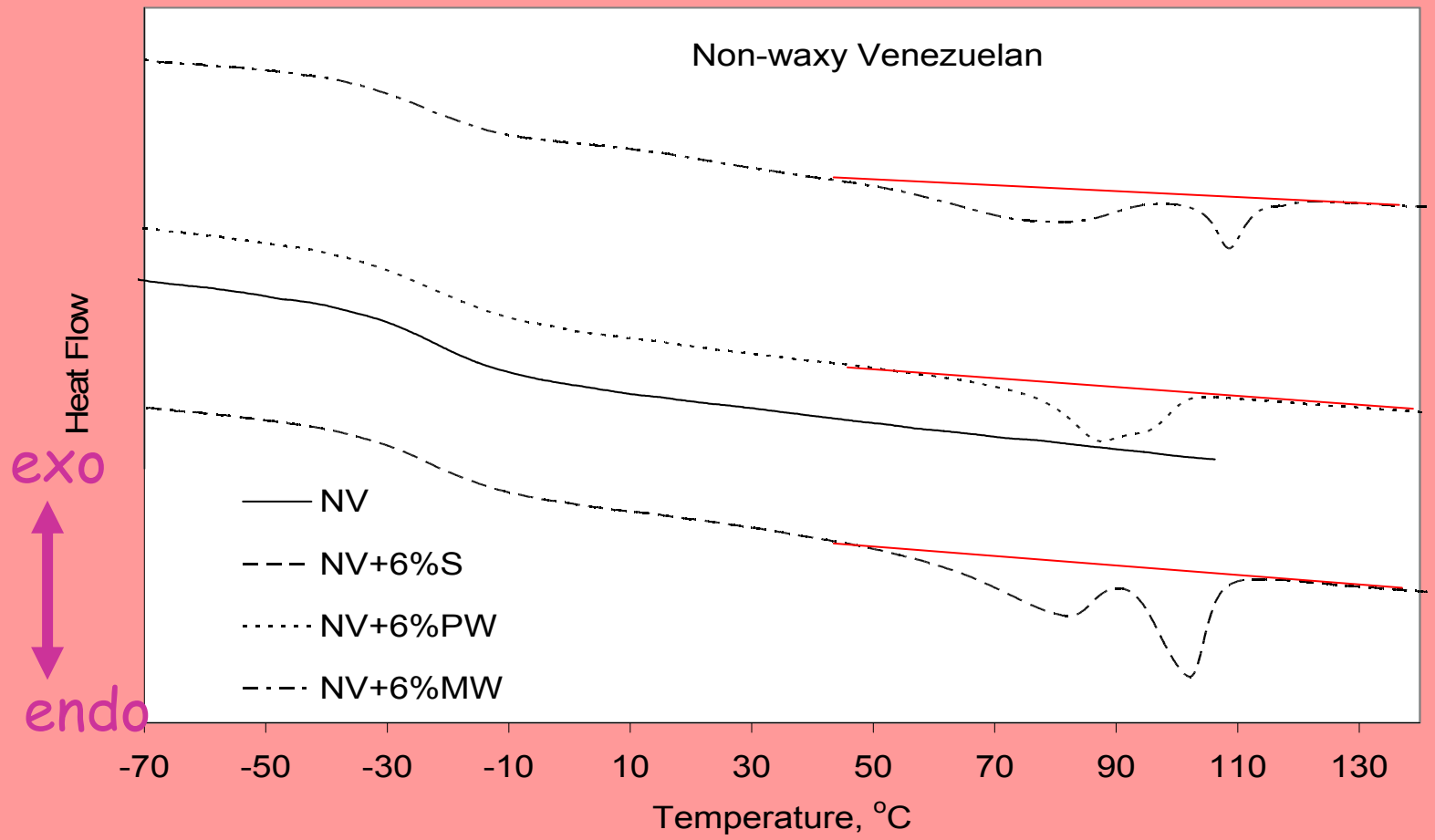
Products?

* FT-paraffin (C_{40} - C_{100} / mp 70-100°C)
* Montan wax (fossil ester wax)
* Polyethylene wax
* Zeolites
* ……

Why?

* Less energy required (softening effect at higher temperatures)
* Less emissions (bitumen fume and - aerosol)
* Other effects?

DSC meling proces



COMMERCIAL wax in bitumen (KTH study 2003-2005)

- Magnitude and type of effect on bitumen rheology depend on the bitumen itself as well as type and amount of additive. Bitumen composition Intended temperature range.
- Effects were mainly of positive or vague nature.
- Evaluate in the laboratory your wax modified bituminous product before using it in practice!
- More studies! (fatigue, adhesion..)

Project about wax additive in polymer modified bitumen for mastic asphalt

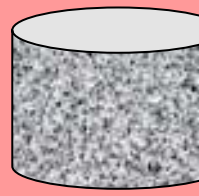
- Expectations: Lower laying temperature, reduced emissions and less CO_2.

- The additive must not have any obvious negative effect.

Project overview

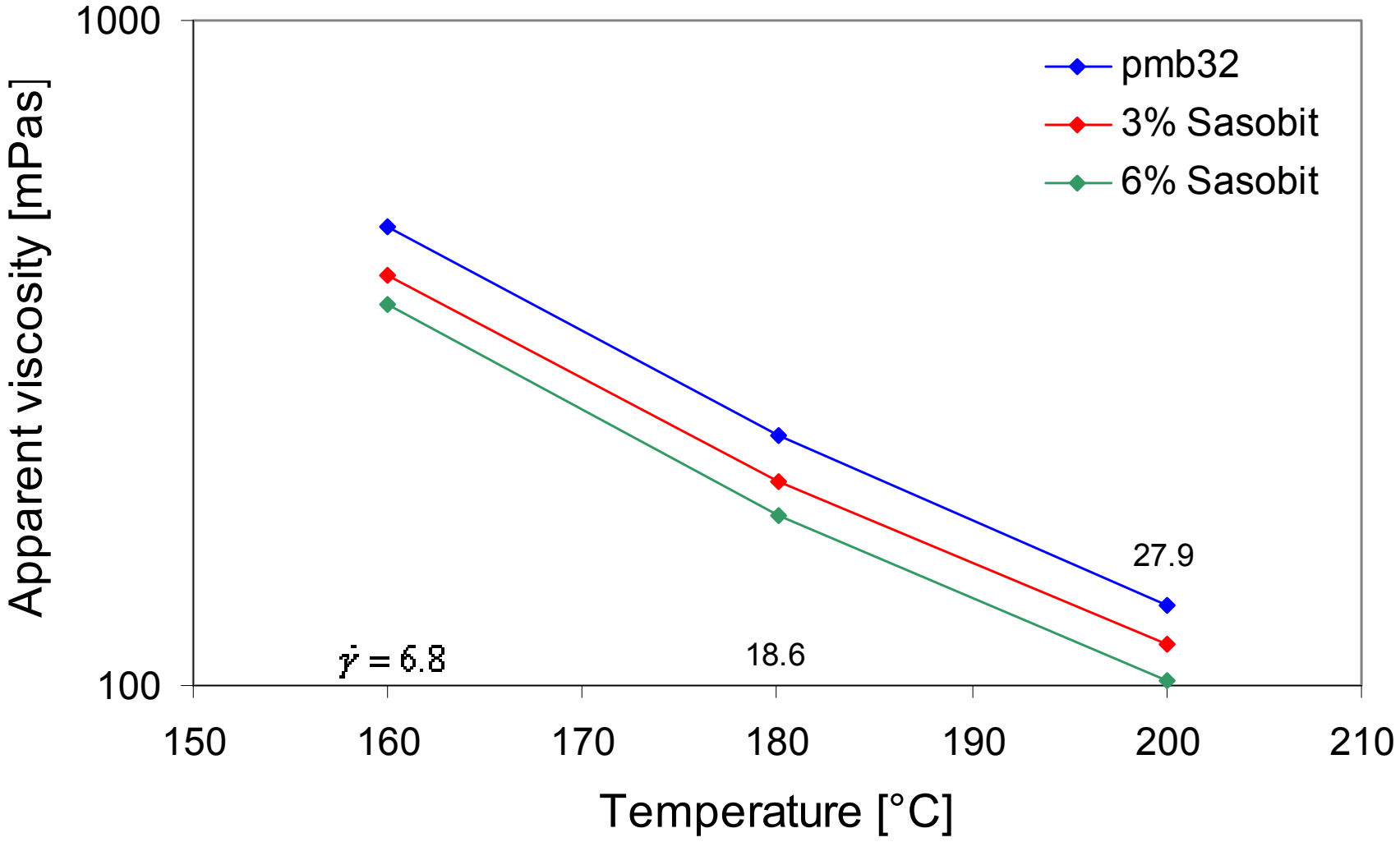
- **Survey** of current knowledge and experience
- **Laboratory study on binder mixtures** (chosen product combinations and wax contents)

- **Laboratory study on mastic asphalt mixtures** (choice based on laboratory test results for binder mixtures)

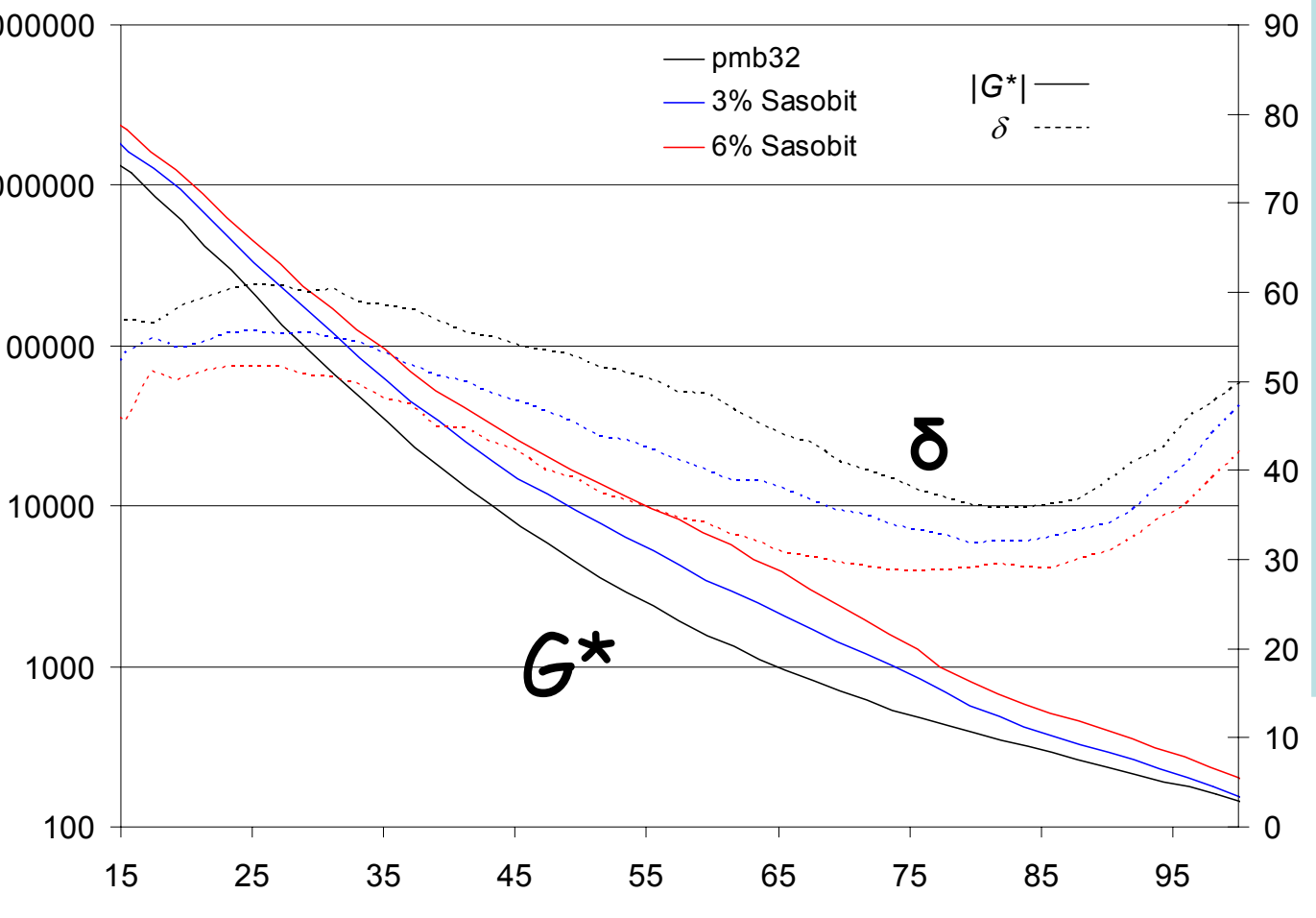


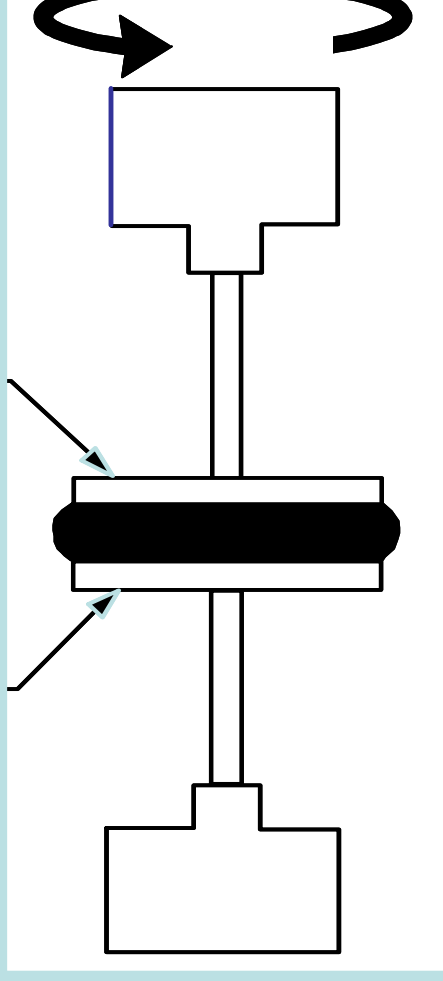
- **Field trials**

Viscosity results



DSR results





Temperature °C

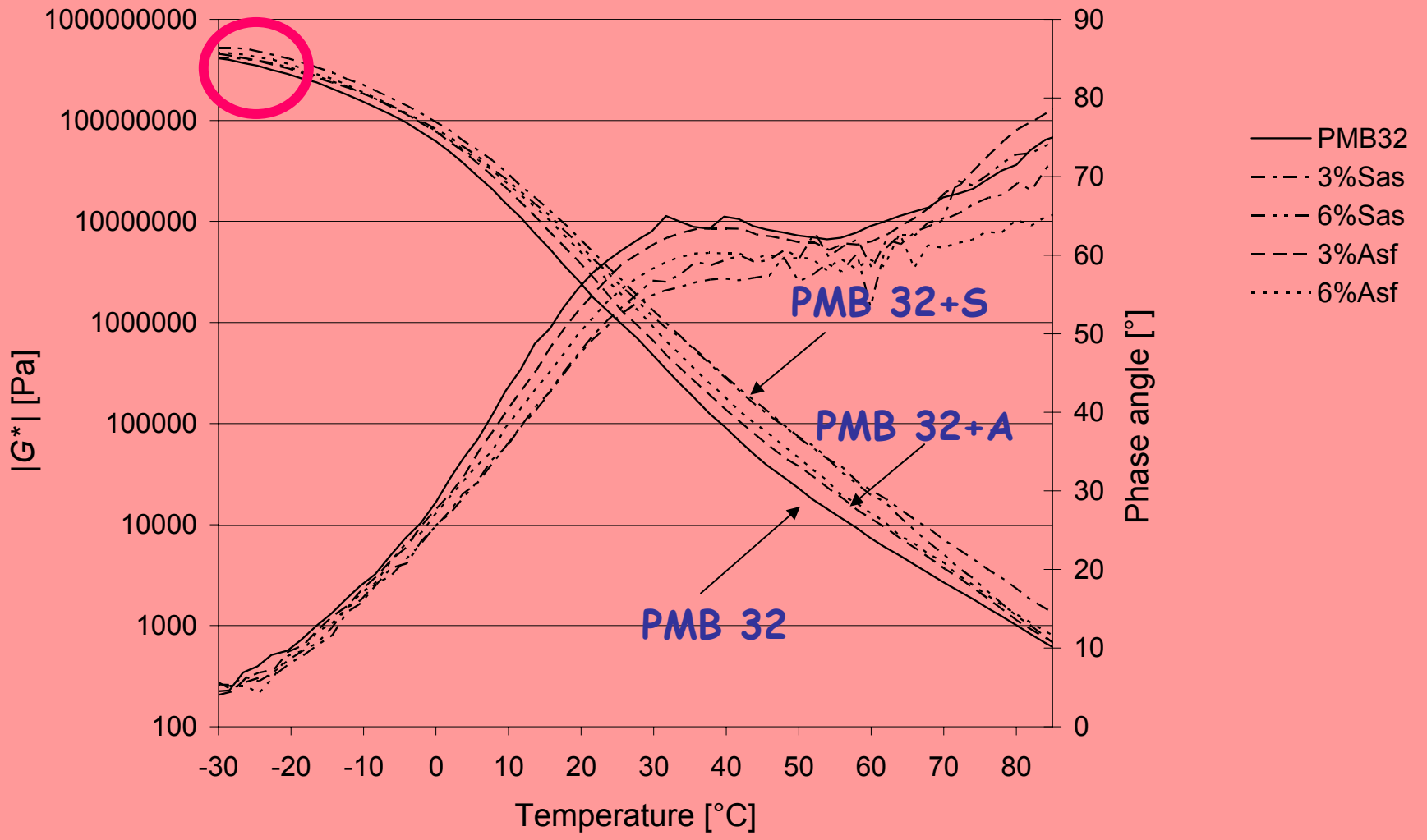
Pmb 32 + Sasobit or Asphaltan A

Additive	Characteristics	Value
Sasobit,	Congealing point (ASTM D 938)	100 (°C)
(FT paraffin wax)	Penetration at 25°C (ASTM D 1321)	<1 (dmm)
	Penetration at 65°C (ASTM 1321)	7 (dmm)
Asphaltan A, (Montan wax)	Solidification point	120-130 (°C)
	Dropping point	125-135 (°C)
	Viscosity at 150°C	5-20 (mPas)

Binder Testing

- Softening point (EN 1427)
- Penetration at 25°C (EN 1426)
- Breaking point Fraass (EN 12593)
- Dynamic viscosity Brookfield at 135 and 180°C (ASTMD442)
- Elastic recovery at 10°C (EN 13398)
- Force ductility at 10°C (EN 13589, EN 13703)
- Storage stability at 180°C (EN 13399)
- Chemical characterization using IR and GPC
- DSR temperature sweep from -30 to +80°C at 10 rad/s (AASHTO TP5)
- BBR-analys at -18 and -24°C (EN 14771)
- DSC

Results original samples - DSR



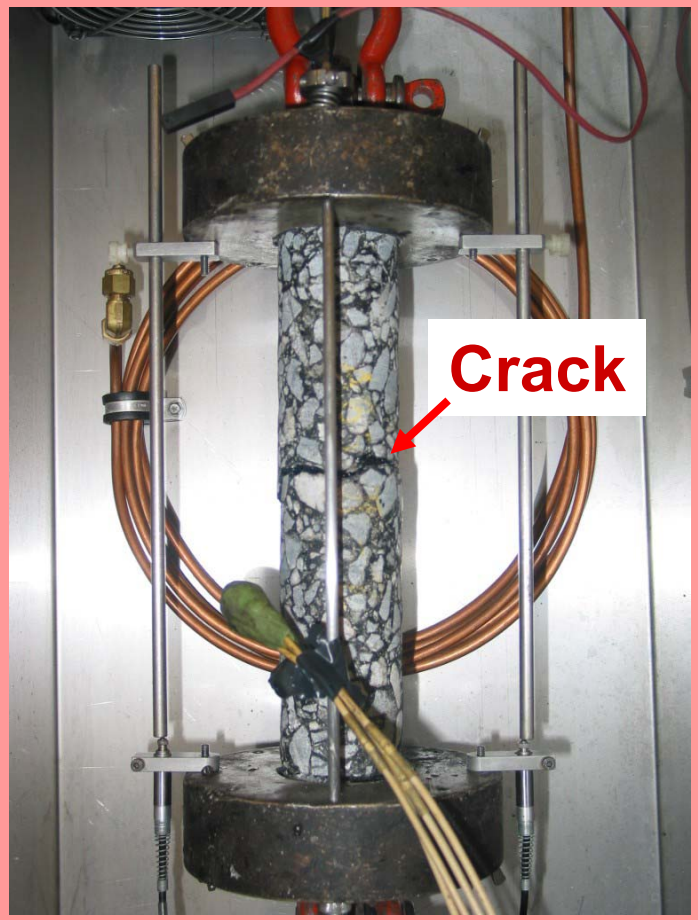
Effects on low temperature behaviour?

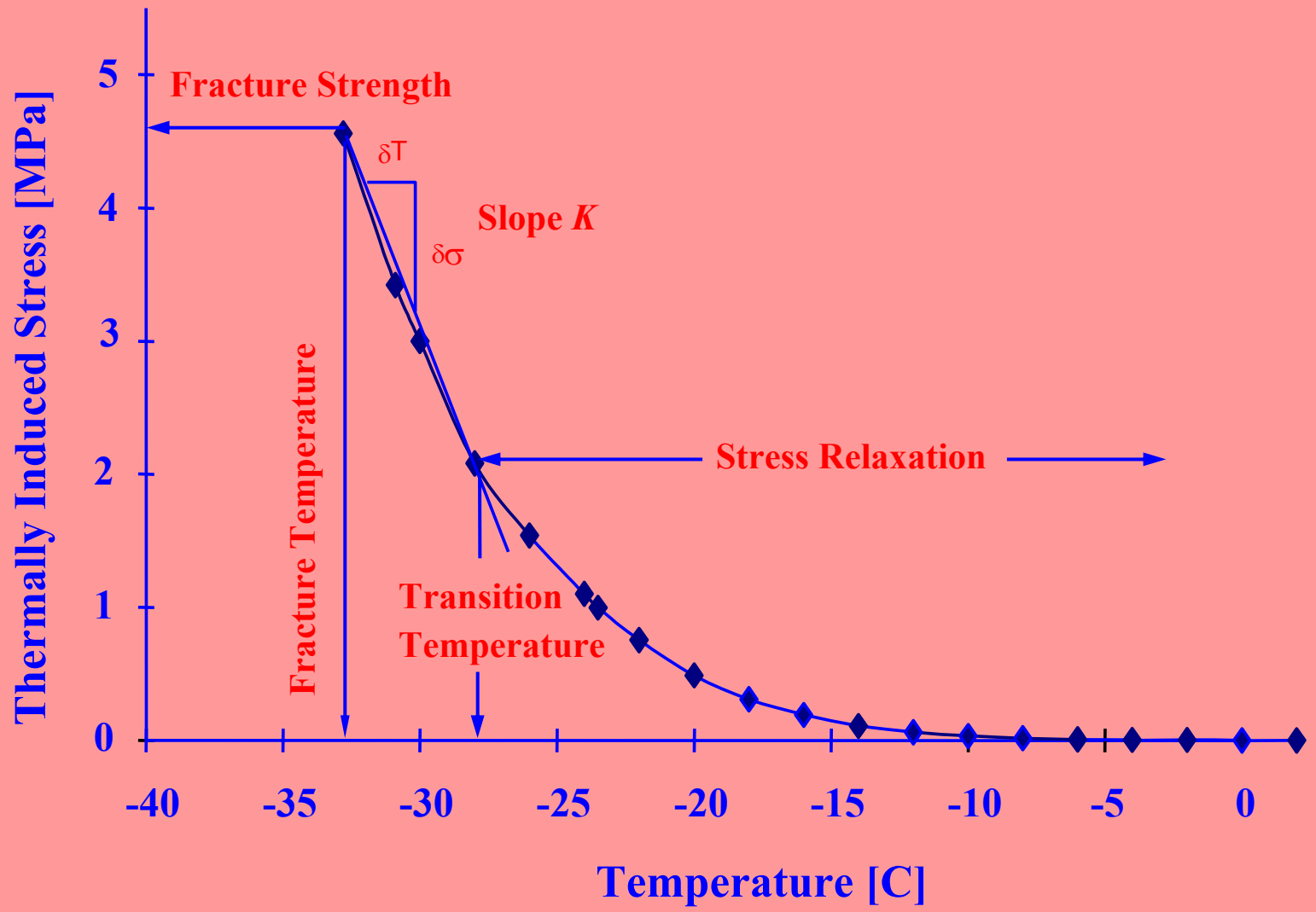
Characteristics	Pmb 32	Pmb +3% S	Pmb 32 +3% A	Pmb 32 +6% S	Pmb 32 +6% A
Breaking point Fraass, °C	-15	-11	-12	-10	-13
BBR -18°C, S MPa /m-value	225/0,319	234/0,282	214/0,318	314/0,260	212/0,296
BBR -24°C, S MPa /m-value	451/0,259	463/0,230	440/0,225	456/0,222	460/0,238
LST,°C	-20	-20	-20	-17	-20
LmT, °C	-20	-16	-19	-12	-18
After RTFOT					
Breaking point Fraass, °C	-11	-11	-14	-7	-14
BBR -18°C, S MPa / m-value	239/0,304	303/0,248	294/0,275	363/0,225	299/0,278
BBR -24°C, S MPa / m-value	461/0,234	540/0,216	434/0,221	574/0,197	527/0,212
LST,°C	-20	-18	-24	-16	-18
LmT, °C	-18	-8	-15	-2	-16

LST is the lower limit temperature at which S is 300MPa

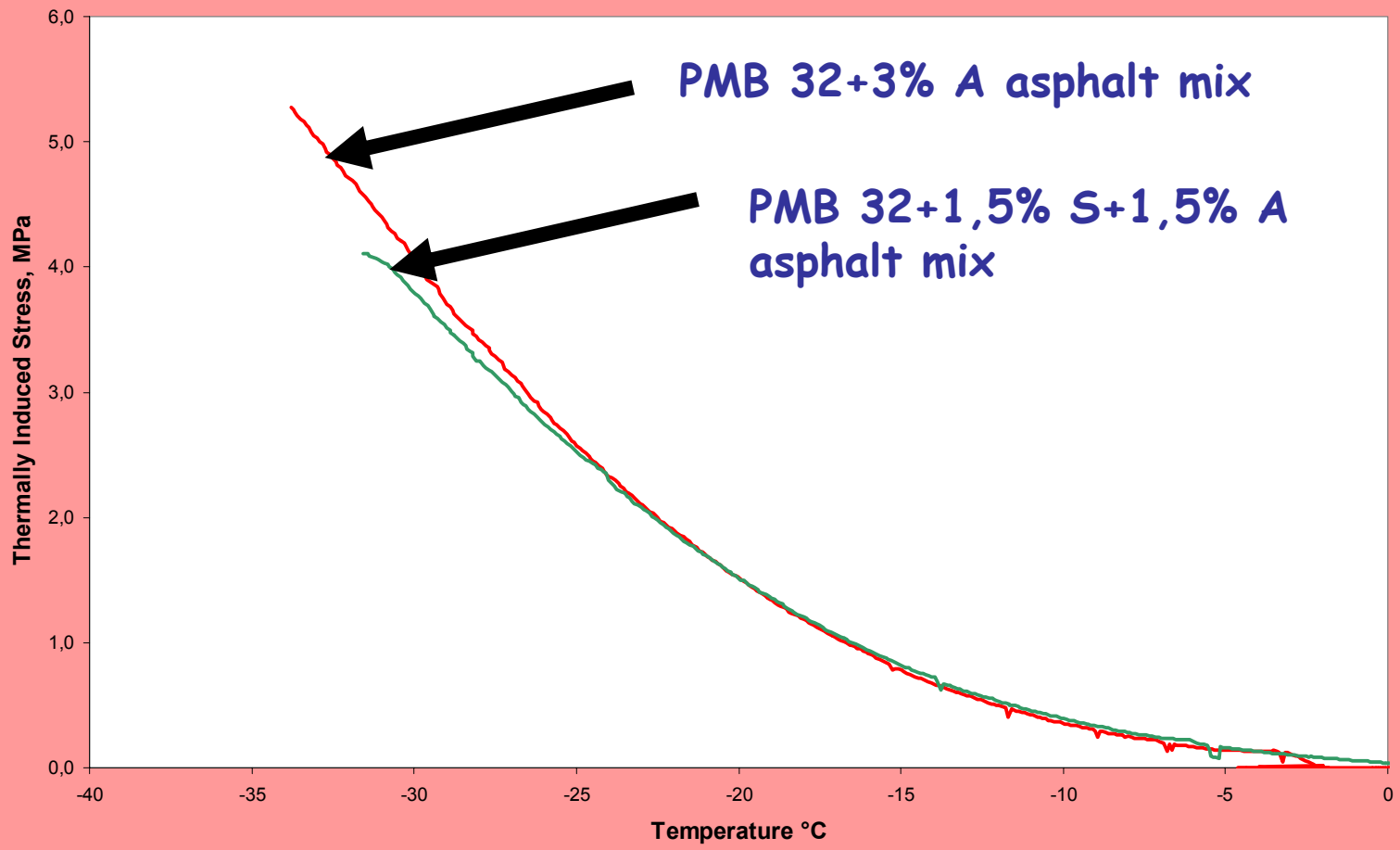
LmT is the lower limit temperature at which m is 0,300

TSRST




Thermally Induced Stress [MPa]
5
4
3
2
1
0
Fracture Strength
δT
δσ
Slope K
Fracture Temperature
Stress Relaxation
Transition
Temperature
-40
-35
-30
-25
-20
-15
-10
-5
0
Temperature [C]

TSRST test results



Laboratory study on mastic asphalt mixtures

- TSRST < -30°C
- Indentation value at +40°C 2-5 mm
- Dimensional stability at +80°C < 1mm
- Slump

Slump test