Heavy Duty Asphalt Concepts

based on FT-Wax Modification

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JRS Fibers for Life.

Examples for heavy duty pavements


Aviation surfaces

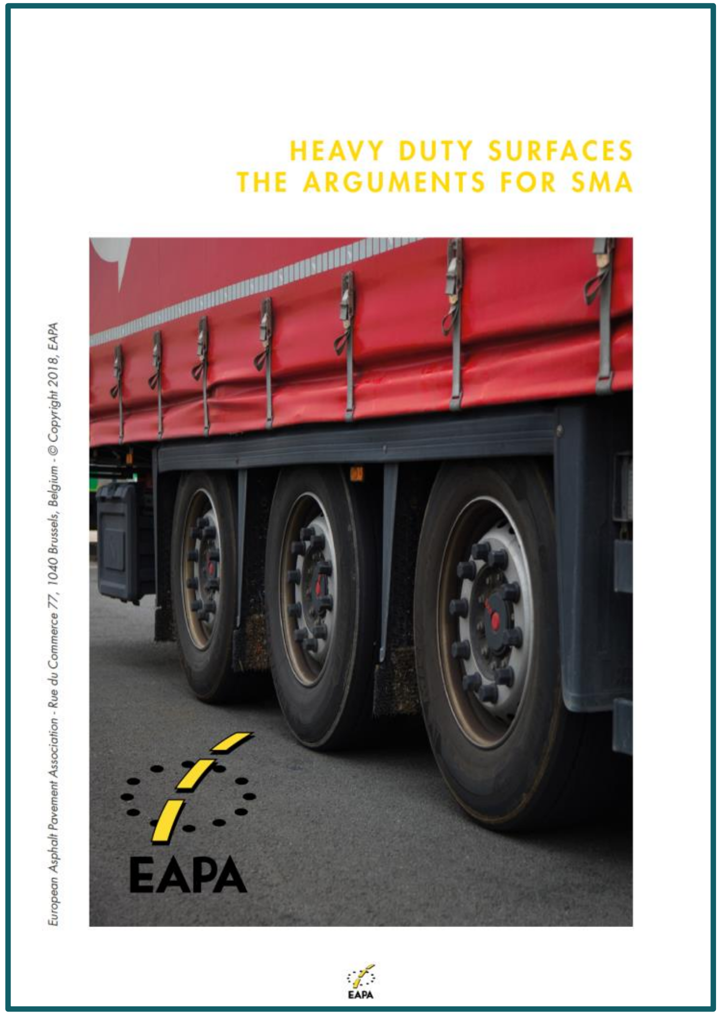

Logistic areas / bus terminals


Container terminals

Situation analysis

- **The need for heavy duty pavements can mostly be traced back to the following factors:**
  - High percentage of aircraft/truck/bus traffic
  - Heavy-weight vehicles – high tire pressure
  - Heavy traffic
  - Maneuvering in narrow curves
- **These factors lead to high static and dynamic loads which must be considered when designing the asphalt.**
- **Standard asphalt mixes may have a short durability due to rutting, deformations and fatigue-cracks.**

Technical Documents



Source: EAPA Home Page

Technical Documents

3.2 High-performance surface courses

The highest stability and durability in surface courses are obtained when Stone Mastic Asphalt (SMA) is used

3.3 High-performance binder courses

Depending on the structure of the pavement, high-performance binder courses can be also obtained by replacing conventional asphalt mixtures, e.g., asphalt concrete by SMA.

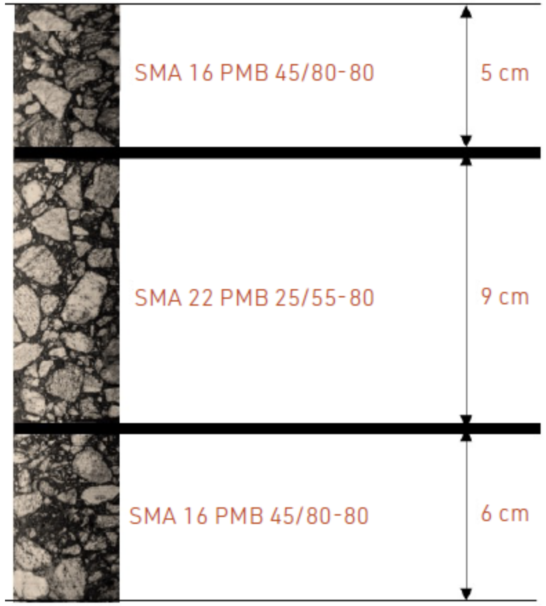
Source: EAPA Home Page

Technical Documents

Source: EAPA Home Page

3.5 New concepts for pavement structures

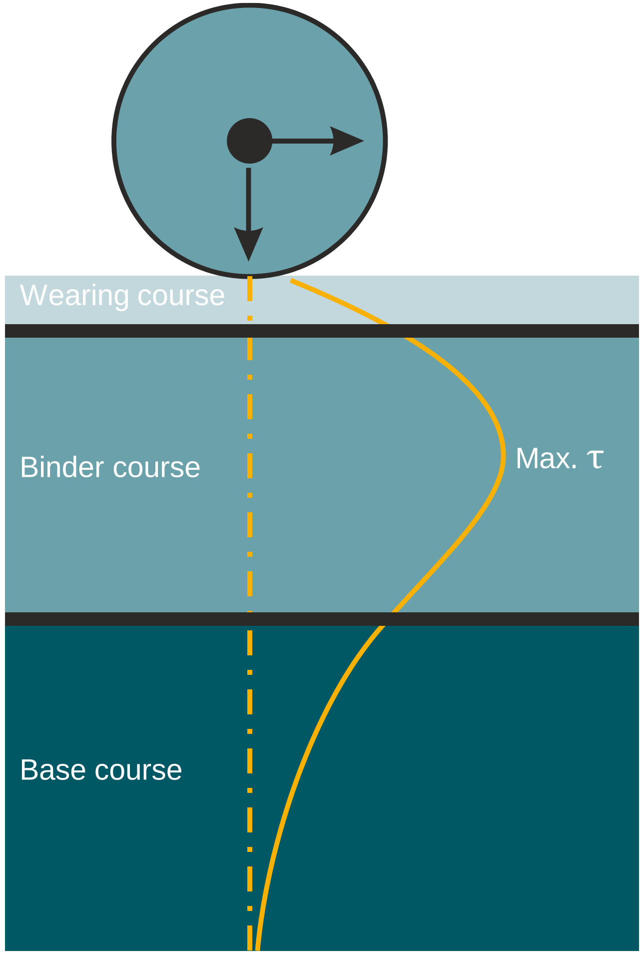
A further evolution of previous points consists of substituting the traditional structure (surface-binder-base course) by a triple SMA layer made with highly polymer-modified bitumens (e.g., PMB 45/80-80 and 25/55-80)



Triple-SMA pavement structure configuration

Situation analysis

- Binder courses (mainly) absorb the shear stress.
- More investment in the binder course will most probably ensure a higher durability of the road.
- However, the design of the binder course must be harmonized with wearing and base course.

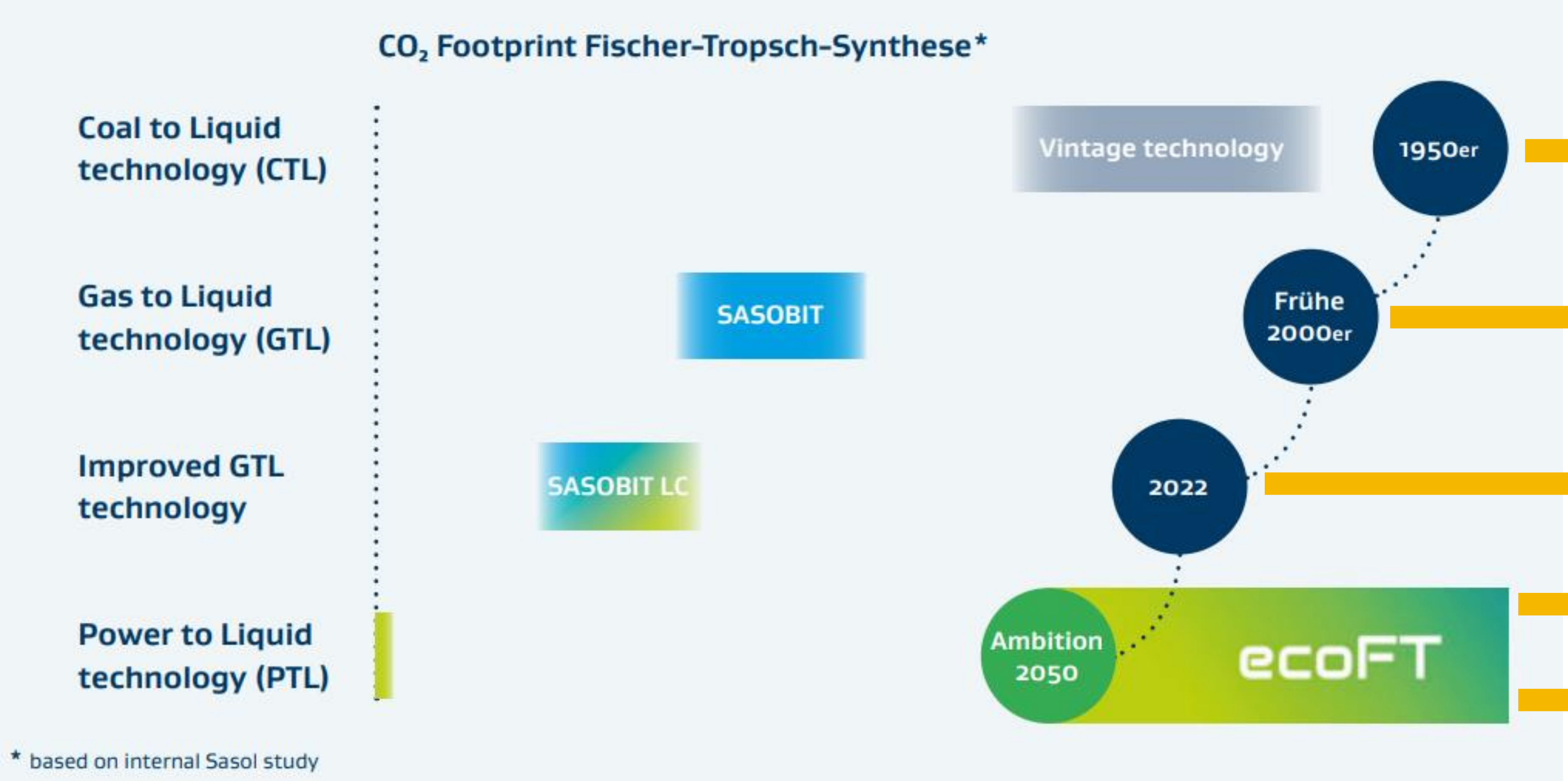


Requirements for heavy duty asphalt pavements

- **To provide durable asphalt pavement in spite of high loads, following measures shall be considered:**
  - Use hard, ideally polymer modified binders
  - Ensure optimal compaction by temperature increase
  - Increase binder content
  - Increase the course thicknesses
  - Test asphalt pavements in performance tests like e.g. Wheel-Tracking-Test

- **How does FT-wax modification impact asphalt pavement's suitability for heavy duty applications?**

Product Carbon Footprints (PCF)



PCF
[$kgCO_2e/kg$]
"Cradle-to-gate"

CTL = 5,2 – 9,5

Up to -75 %

SASOBIT = 2,3 – 3,4

REDUX = 1,6 – 2,6

SASOBIT LC = 1,3 – 1,9

Green hydrogen as an energy source

Bio gas as raw material

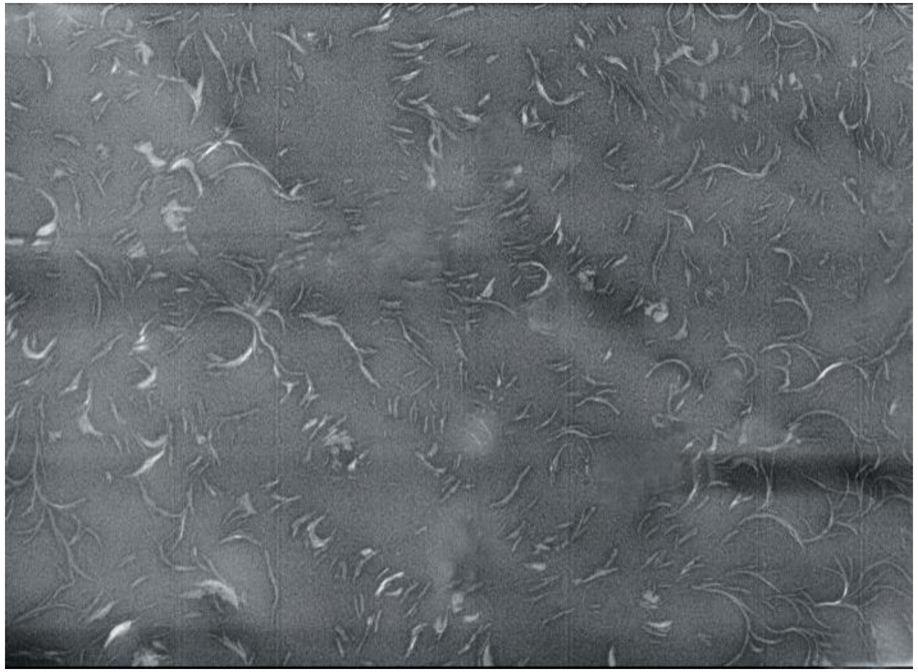
Sasol produces in specialized FT refineries in South Africa. Transport is carried out by container ships from Durban to Hamburg, releasing an additional 0.1247 kgCO2e/kg [1 a, 1 b]. In comparison: Hamburg – Munich = 0,0535 $kgCO_2e/kg$

Solutions for heavy duty asphalt pavements

- **FT-wax has an increasing effect on Softening Point R&B and a decreasing effect on Needle Penetration at 25 °C.**
- **The higher the FT-wax content the stronger the stiffening effect.**
- **In practice a dosage of 2,5 – 4,0 % FT-wax by binder content have proven for heavy duty applications.**

Solutions for heavy duty asphalt pavements

- **During cooling phase FT-wax starts to crystallize at 90 °C and forms a lattice structure in the bitumen.**
- **This lattice structure has a stiffening effect.**
- **The stiffening effect significantly improves the resistance to permanent deformation at higher temperatures.**

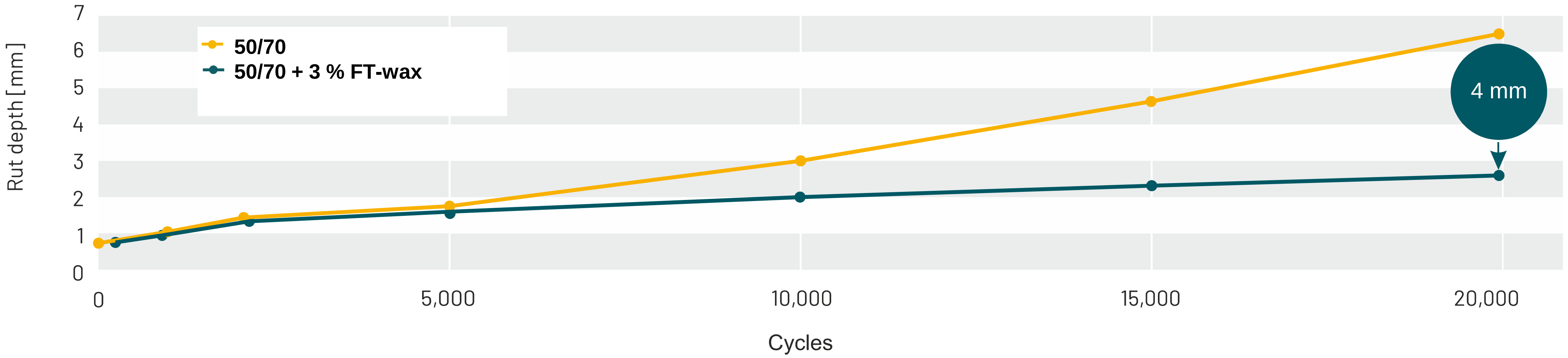


REM picture of 50/70 + 4.0 M.-% FT-wax

- **FT-wax improves binder's suitability for the use in heavy duty applications.**

Solutions for heavy duty asphalt pavements

Wheel-Tracking-Test SMA 11 S*

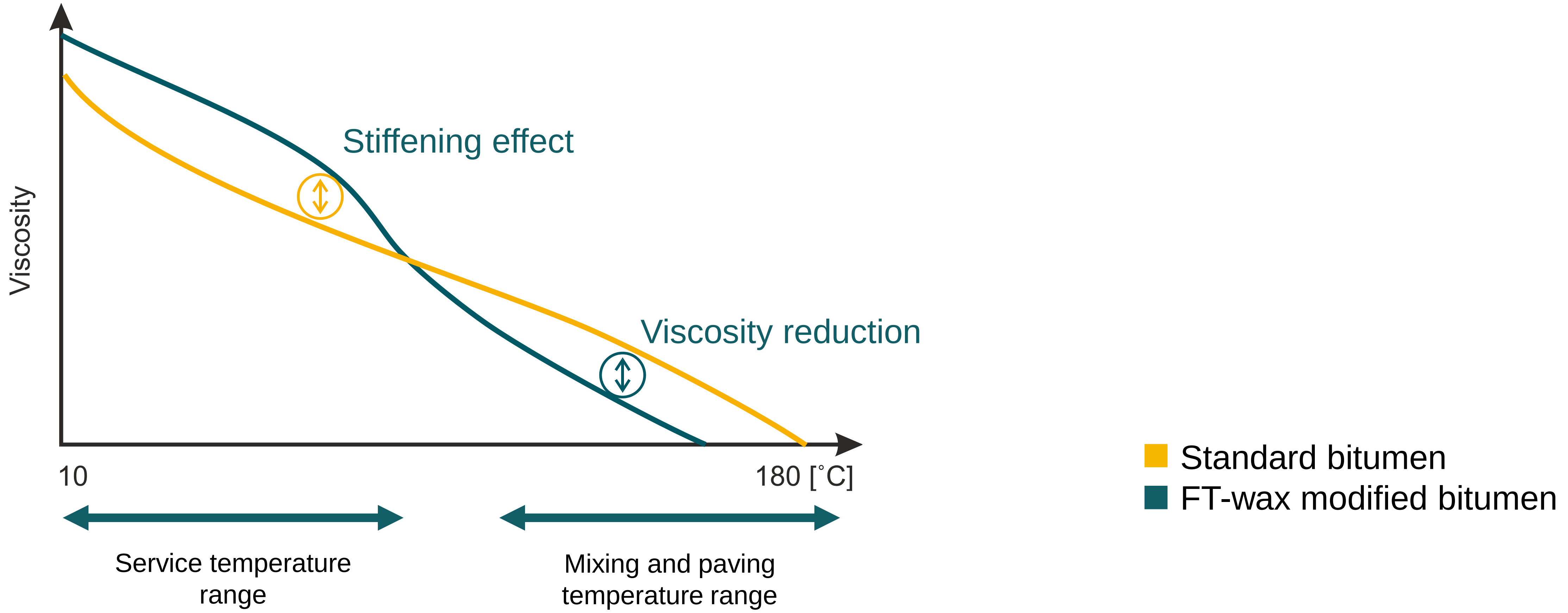


***Steel wheel in water bath at 50° C**

Solutions for heavy duty asphalt pavements

- **PmB have proven well for heavy duty applications:**
  - Deformation resistance.
  - Fatigue resistance.
  - Cold temperature resistance.
- **Challenges of polymer modified pavements:**
  - Higher temperatures are necessary to ensure good workability and compaction.
  - Consequences: binder ageing, additional costs, higher emissions, impairing polymer properties.

Solutions for heavy duty asphalt pavements



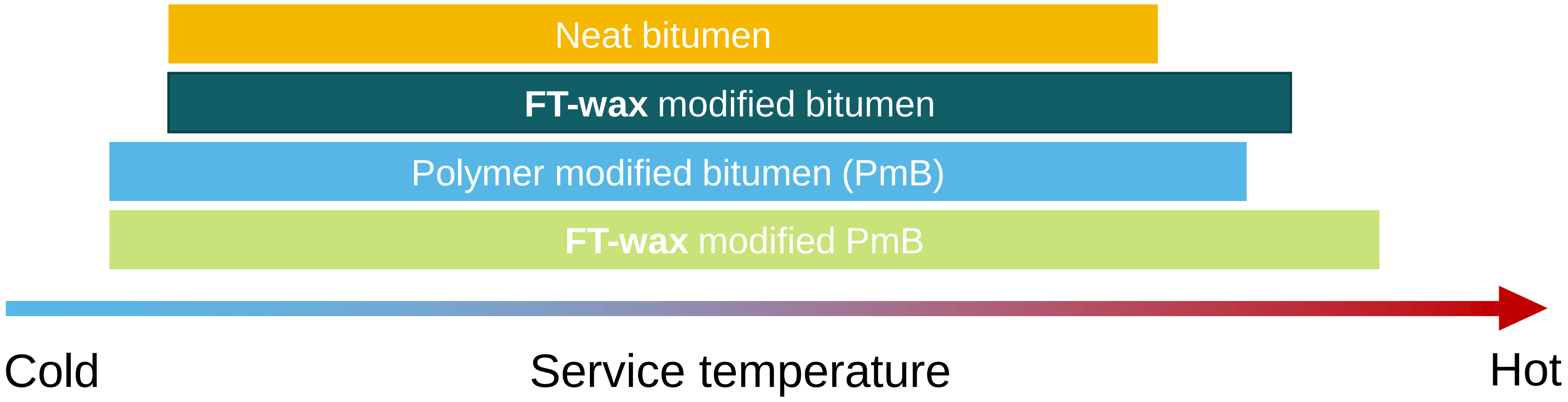
› **The viscosity reducing effect of FT-wax modification can be used to overcome the challenges of polymer modified binders during mixing and paving.**

Solutions for heavy duty asphalt pavements

› **The combination of FT-wax and PmB represents a superior binder concept:**

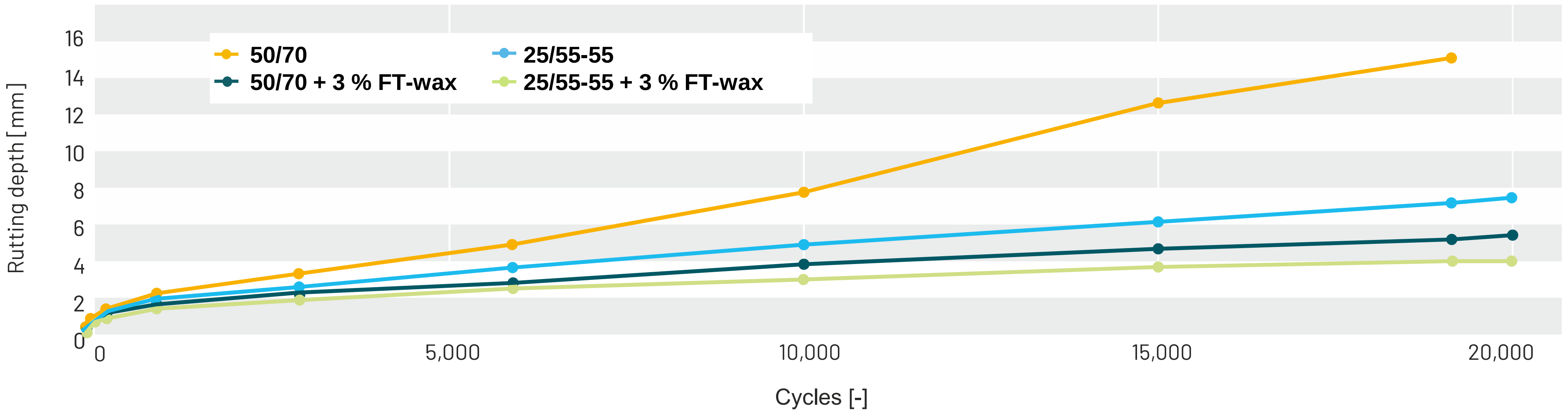
- ✓ Viscosity reducing effect of **FT-wax** ensures optimal workability.
- ✓ Viscosity reducing effect of **FT-wax** allows for avoiding increase of temperature.
- ✓ Stiffening effect of **FT-wax** enhances deformation resistance even more.
- ✓ Low temperature performance is not impaired by **FT-wax** but improved by polymers.

Qualitative change of plasticity range caused by modification:



Solutions for heavy duty asphalt pavements

Hamburg Wheel-Tracking-Test, Steel wheel, water bath 50 °C, SMA 8 S



› **FT-wax modified bitumen performs better than PmB.**

› **FT-wax modified PmB provides the best performance.**

Solutions for heavy duty asphalt pavements

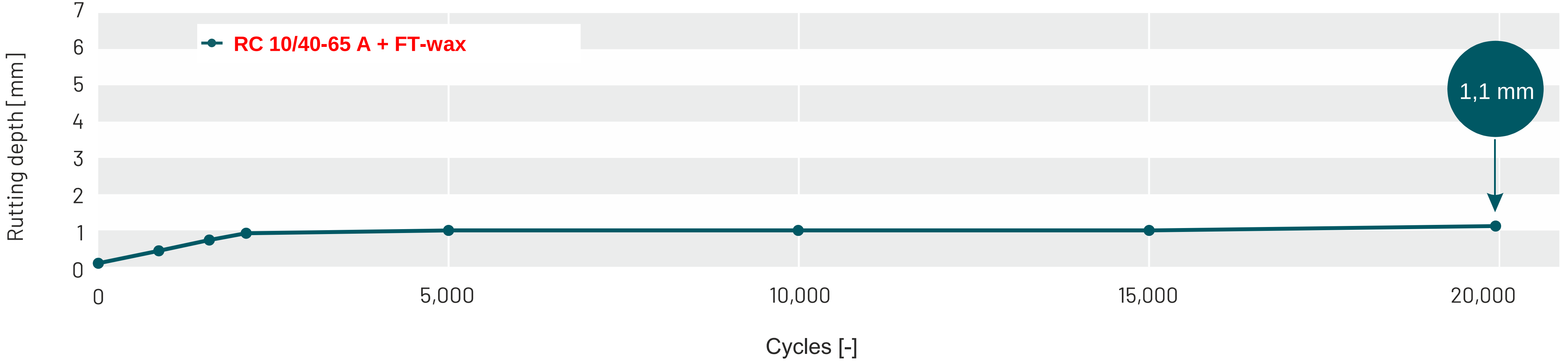
	Binder	Rutting depth* [mm]
AC 16 B S	10/40-65 A	2,4
	25/55-55 A RC + 3 M.-% **FT-wax**	2,1
SMA 8 S	25/55-55 A	4,5
	25/55-55 A RC + 3 M.-% **FT-wax**	2,3

***Steel wheel in water bath at 50° C**

- **Core samples were taken out of a road and were tested in Hamburg Wheel Tracking-Test.**
- **The softer 25/55-55 A RC + FT-wax shows a better performance than the harder 10/40-65 A.**
- **The deformation resistance of 25/55-55 A RC + FT-wax shows a significant advantage in comparison to 25/55-55 A.**

Solutions for heavy duty asphalt pavements

Hamburg Wheel-Tracking-Test, steel wheel, waterbath at 60 °C, AC 16 B S



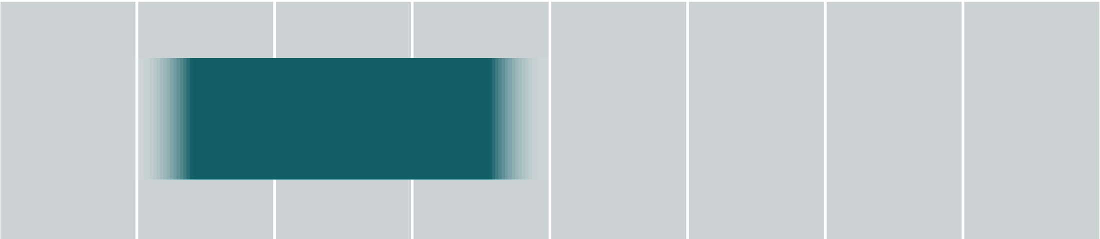
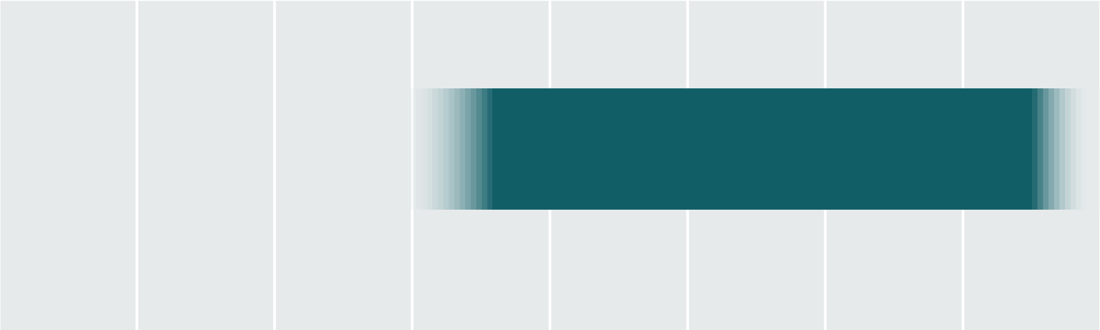
› **Extraordinary results of FT-wax modified binders in Wheel-Tracking-Test; even at 60 °C.**

Conclusion

› **The use of FT-wax is a proven, cost-effective and superior alternative to conventional asphalt mixes that enable heavy duty pavements.**

Conventional measure	FT-wax alternative	Benefits of FT-wax alternative
Use of hard binders/PmB	**FT-wax** modified bitumen/PmB provide a comparable or even better performance in rutting resistance	✓ Good workability and high rutting resistance ✓ Production of **FT-wax** modified bitumen can be done at the mixing plant
Ensure optimal compaction by temperature increase	**FT-wax** improves workability without temperature increase	✓ Less ageing ✓ Extended service life ✓ No additional costs for energy
Increase binder content/course thickness	**FT-wax** improves deformation resistance as well as workability	✓ No additional costs for raw material and handling

Conclusion

Recommended dosage for FT-wax in M.-% by weight of the bitumen 1,0 1,5 2,0 2,5 3,0 3,5 4,0	Benefits of FT-wax-modification
	› Improves workability › Reduces the risk of compaction failures › High mixing-temperatures can be avoided › Enables optimal compaction, thus better performance › Slightly improved deformation resistance
	› Improves workability › Reduces the risk of compaction failures › High mixing-temperatures can be avoided › Enables optimal compaction, thus better performance › Significantly improved deformation resistance › Softer base bitumen can be used without impairing the performance, yields better low temperature performance

Generally the base bitumen grade must be carefully chosen with regard to the climate conditions, mostly the frost zone. As **FT-wax** improves the deformation resistance the plasticity range is extended and therefore the service temperature interval is enlarged.

How to modify?

- Terminal blended binder

How to modify?

- **At the mixing plant**
  - Pure FT-wax
    - Bitumen scales
    - Bitumen stream
    - Melting device
    - Pug mill

How to modify?

- **At the mixing plant**
  - FT-wax/fiber pellet
    - Fiber dosing unit

- **VIATOP plus WMA**
  - VIATOP plus C 25
  - VIATOP plus CT 40
  - VIATOP plus CT 80-AC

Case studies – examples

- **Airports**
  - Frankfurt International Airport 2004 – 2017
  - Hamburg Airport 2001 & 2003
  - Airport Berlin Brandenburg 2004
  - Airbus Factory Runway Hamburg Finkenwerder 2003
  - Svalbard Airport Longyearbyen 2006
  - Summary

- **Container Terminals**
  - Hamburg Tollerort
  - Hamburg Eurogate
  - Hamburg HHLA Burchardkai
  - Summary

- **Bus terminals/lanes**
  - Remmscheid

Case studies – Frankfurt International Airport – 2004 - 2017

- **Since 2004 runways were renewed according following procedure:**
- **The old concrete runway had to be removed and replaced by asphalt mix in very short time slots.**
- **Works were only possible during the night flight ban between 10:30 pm and 6:00 am.**
- **Time slot of 7 ½ hours for demolition of the concrete and paving the asphalt mix.**
- **First plane landed directly after the end of the working time slot.**
- **Delays would have caused major delays in the European air traffic.**

Fraport

Case studies – Frankfurt International Airport – 2004 - 2017

- **Renovation of Runway North, Sectors 1 & 2.**
- **Size of project approx. 100.000 m².**
- **Tonnage approx. 1.500 to/nightshift.**
- **Asphalt construction:**
  - 24 cm AC 32 T S, **30/45 + 4 % FT-wax** + **fibers**
  - 24 cm AC 32 T S, **10/40-65 A + 4 % FT-wax** + **fibers**
  - 12 cm AC 22 B S, **10/40-65 A + 4 % FT-wax** + **fibers**
  - After approx. 150 m of runway are finished 4 cm are milled off and are replaced with:
  - 4 cm **SMA 11 S**, **25/55-55 A + 4 % FT-wax** + **fibers**

Fraport

Case studies – Hamburg International Airport

- **First runway in 2001.**
- **Second runway in 2003.**
  - Both cases: tender requests the renovation of binder and wearing course.
  - Hamburg is situated in a very wet climate, frequent freeze/thaw cycles and heavy use of de-icing fluids.
  - A very dense and deformation resistant asphalt mix is necessary.
  - **FT-wax** enables higher compaction rates and therefore ensures the fulfilment of the high requirements.

Case studies – Hamburg International Airport

- **Project size 65.000 m²; 6.670 t**
- **Asphalt construction**
  - 4 cm, **SMA 11 S** wearing course
  - Binder: **50/70 + 3,0 M.-% FT-wax**
    - Softening Point R&B: 82 °C
    - Binder content in the mix: 7,0 %
    - Mixing temperature: 150 – 160 °C
    - Paving temperature: 140 – 150 °C
- **Asphalt test results**
  - Void content: 3,3 %
  - Wheel tracking test (steel wheel, water bath @ 50 °C, 20.000 cycles): 3,2 mm

Case studies – Airport Berlin Brandenburg

- **Schönefeld runway 07R/25L in 2004.**
- **Project size: 135.000 m², approx. 45.000 t hot mix.**
- **Asphalt construction:**
  - Subgrade: old base course.
  - Binder course: 12 cm AC 16 B S + **0,2 % fibers**, paved in two layers.
  - Binder: **25/55-55 A + 3 M.-% FT-wax**.
  - Surface course: 3 mm antiskid-coating.
- **Purpose of using FT-wax:**
  - Significantly improved deformation resistance.
  - Good workability despite ambient temperatures of -2 °C.
  - Ensure optimal compaction.

SXF FLUGHAFEN BERLIN BRANDENBURG

Case studies – Airbus factory runway Hamburg Finkenwerder

- **Airbus had to renew their runway because of the delivery of the A 380.**
- **No taxi system, the planes need to turn on the runway as well.**
- **The turning area needs a special asphalt mix design because of the high shear forces. Those are caused by 180° turns on a small diameter.**
- **Purpose of using FT-wax:**
  - Significantly improved deformation resistance.
  - Optimal compaction to ensure very dense asphalt mixes especially in the turning area.

AIRBUS

Case studies – Airbus factory runway Hamburg Finkenwerder

- **Subgrade: concrete slabs.**
- **Concrete slabs are covered by asphalt mix, joints were cut and cuts were resealed with flexible mastic.**
- **Asphalt construction for the runway:**
  - Overlay: 5 cm AC 11 D S
  - Binder: **25/55-55 A + 2,5 M.-% FT-wax** + adhesion promoter + **0,2 % fibers**

Case studies – Airbus factory runway Hamburg Finkenwerder

- **Asphalt construction for the turning area:**
  - Overlay: 5 cm AC 11 D S.
  - Binder: Endura Z2 (**incl. FT-wax**) + **0,2 % fibers**.
  - Binder content: 6,4 M.-%.
- **Asphalt test results turning area:**
  - Hamburg Wheel-Tracking-Test, water bath @ 50 °C, 20.000 wheel passes: 2,43 mm

Case studies – Svalbard Airport Longyearbyen

- **The airport is situated on the island Svalbard.**
- **Climate conditions are very special:**
  - Average temperature winter: -14 °C
  - Average temperature summer: +6 °C
  - Annual average temperature: -7 °C
  - Maximum temperature (1979): +21 °C
  - Minimum temperature (1986) -46 °C
  - Temperature drops/increases of 15 K or more can happen within a few hours.

Case studies – Svalbard Airport Longyearbyen

- **Renovation of the runway in 2006.**
- **Main challenges:**
  - Low temperatures while paving and production.
  - Fast winds.
  - Wide service temperature range:
    - Very low temperatures in the winter.
    - Eternal sunshine in the summer.
  - High deformation resistance due to the heavy load caused by planes.

Case studies – Svalbard Airport Longyearbyen

- **Choice of the binder:**
  - No use of SBS modified bitumen because these binders are difficult to process, especially under the given circumstances.
  - Usage of very soft bitumen (Pen 430) to ensure low temperature performance.
- **Purpose of using FT-wax:**
  - Extending the service temperature range by improving the deformation resistance at high temperatures.
  - Providing process reliability with regards to the severe weather conditions.

Case studies airport - summary

- **Airport projects generally need special asphalt mix design because of the following requirements:**
  - ✓ Tight timeline must be met.
  - ✓ Process reliability is essential.
  - ✓ Heavy loads demand for a high performance and optimal compaction.

- **FT-wax helps to meet these special requirements for airport pavements, this has been shown in various projects all over the world!**

Case studies – container terminal Hamburg-Tollerort

- **Size:**
  - 377.000 m² in 2004, 600.000 m² nowadays
  - 950.000 TEU/p.a.
- **70.000 m² were built in 2004.**
- **Subgrade:** Reclaimed ground/sand with a compacted layer of 32 mm gravel on top.
- **Asphalt mix construction:**
  - Binder course: 8 cm AC 16 B S with **10/40-65 A RC + 4,0 M.-% FT-wax**.
  - Surface course: 6 cm **SMA 16** with Nynas Endura Z2 **(incl. FT-wax)**.

Case studies – container terminal Hamburg-Tollerort

Case studies – container terminal Eurogate Hamburg

- **Size**
  - 1,7 Mio m² (2010), 2,1 Mio TEU/p.a.
  - 50.000 m² were built in summer 2005.
- **Subgrade: Sand (well settled) with a compacted layer of 32 mm gravel on top.**

Case studies – container terminal Eurogate Hamburg

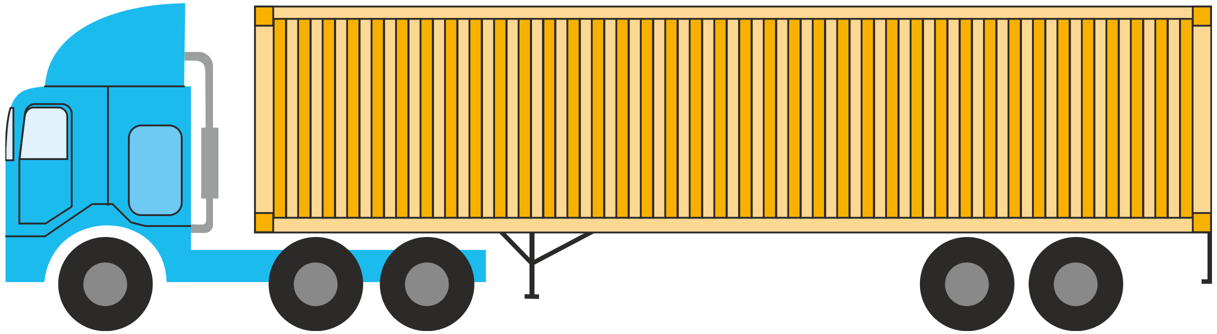
- **Asphalt mix construction:**
  - Base course: 15 cm AC 22 B S, 50 % graded RAP.
  - 2 % neat binder, **50/70 + 4,0 M.-% FT-wax**
  - Hamburg Wheel-Tracking-Test: 3,3 mm rut depth*
- **Surface course:** 3 cm AC 8 D S, 20 % graded RAP:
  - Binder: Nynas Endura Z2 (**incl. FT-wax**)
  - Hamburg Wheel-Tracking-Test: 2,7 mm rut depth*

***Steel wheel in water bath @ 60° C**

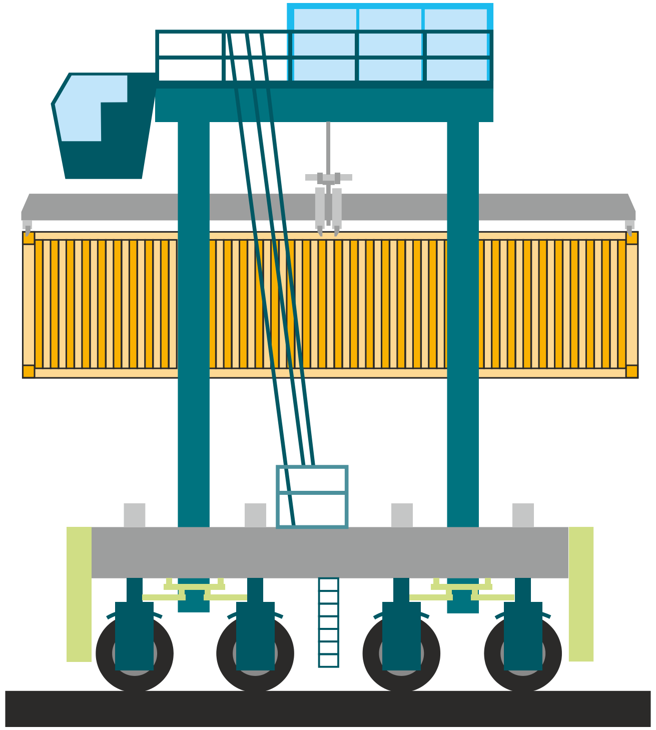
Case studies – container terminal HHLA Burchardkai Hamburg

- Initial project for FT-wax application in container terminals:
- Realization in 2000, review in 2007.
- 88 % growth in container movements from 2000 to 2007.
- Growth in container movements could not be compensated by increasing the area.
- Requirements for the asphalt mix design were distinguished in terminal roads and the extremely loaded HO-Tracks.

Case studies – container terminal HHLA Burchardkai Hamburg



- Truck weight: 40 t
- Load per axle: 8 t



- Van carrier weight: 95 t
- Load per axle: 23,75 t

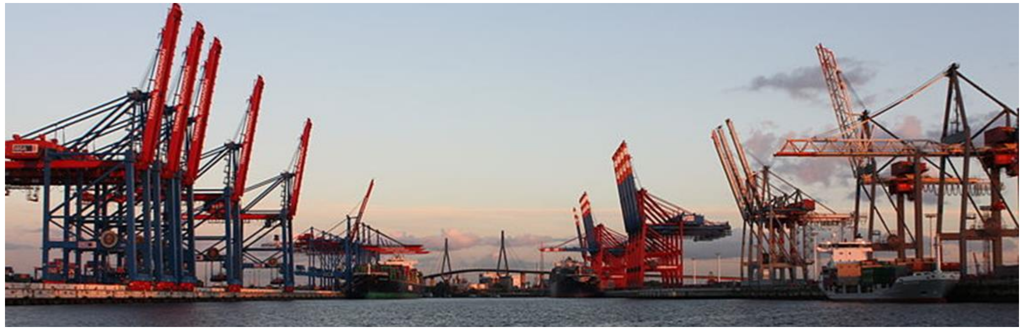
Case studies – container terminal HHLA Burchardkai Hamburg

- **HO-Tracks:**
  - Special area where van-carrier load/unload a truck with full containers.
  - Highest loads occur because narrow tracks are constantly exposed to enormous wheel pressure of the Van-Carriers.
  - Van-Carrier operate 365 days a year, 24 hours a day.
- **Initially, HO-tracks were paved with a standard “road” asphalt without FT-wax**
  - 8 cm binder, 6 cm SMA.
  - Within a few months extreme deformations occurred!

Case studies – container terminal HHLA Burchardkai Hamburg

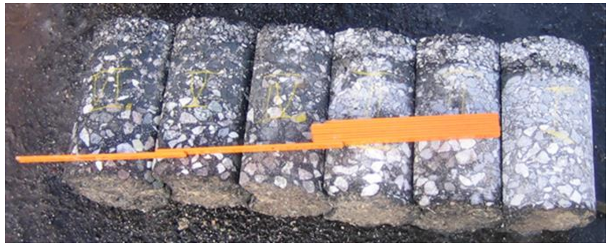
- **Following actions were conducted to improve deformation resistance:**
  - Using very hard PmB (**10/40-65 A RC**).
  - Using **4,0 M.-% FT-wax**:
    - Improve workability without increasing the mixing temperature.
    - Improve deformation resistance in service temperature range.
- **Resulting asphalt mix construction:**
  - Base course: 10 cm AC 22 T S, 4,1 mm rut depth*.
  - Binder course: 10 cm AC 16 B S, 1,5 mm rut depth*.
  - Surface course: 4 cm **SMA 11 S**, 2,7 mm rut depth*.

***Steel wheel in water bath @ 60° C**



Case studies – container terminal HHLA Burchardkai Hamburg

- **After seven years of service the deformation was determined by analyzing three cross sections.**
- **Cross sections were taken from the areas where the van carriers usually start and stop.**
- **The deformation was 13 mm in average and was split to the courses as follows:**
  - Sub grade: 35 %
  - Base course: 20 %
  - Binder course: 0 %
  - Surface course: 45 %



- **With regards to the massive loads caused by the van carriers and the growth in container movement the deformations are relatively low!**

Case studies – container terminals summary

- **Container terminal projects usually need special asphalt mix design because of the following requirements:**
  - ✓ Extremely high loads must be absorbed.
  - ✓ Optimal compaction is very important.
  - ✓ Process reliability is essential.
- **FT-wax modification helps to meet these special requirements for container terminal asphalt pavements, this has been shown in various projects all over the world!**

Case studies – Bus terminal Remscheid

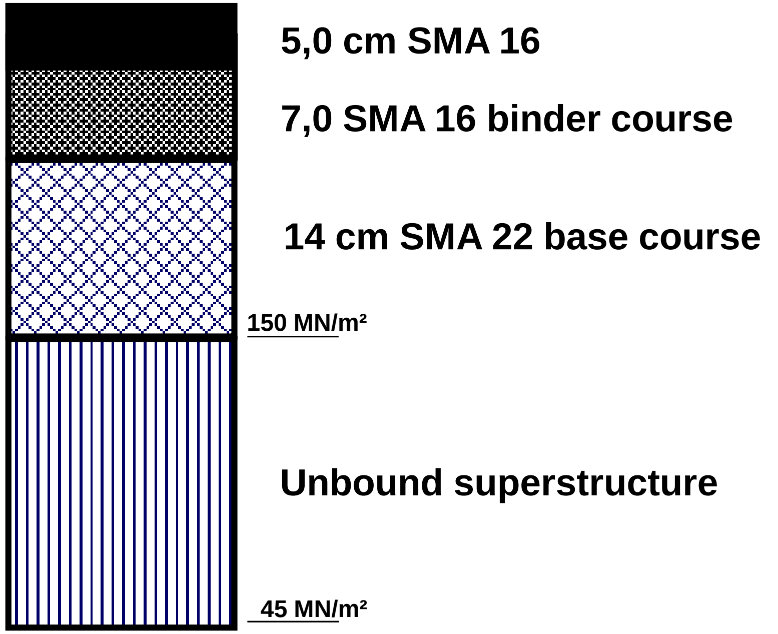
- **Initial situation:**
  - Severe deformations
  - Rutting
  - Cracking
  - Major maintenance or renewal at east every three years

- **Causes:**
  - Very high horizontal and vertical loads
  - both static and dynamic
  - Lane driving
  - Steep gradient
  - Radiation heat by busses

Case studies – Bus terminal Remscheid

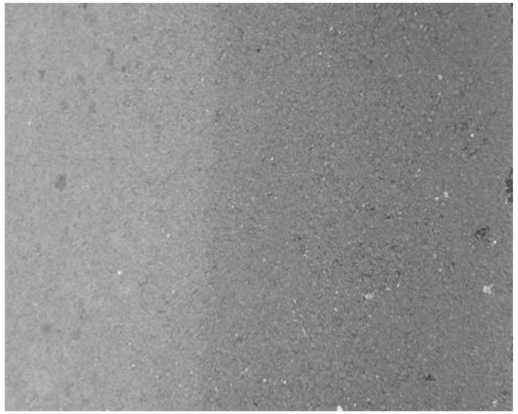
Concept for very high horizontal and vertical loads
(Bus terminals/lanes)

Wearing course with increased thickness and hard binder with increased polymer and FT-wax content for both wearing and binder course.

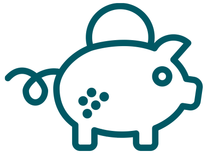


Case studies – Bus terminal Remscheid

After 7 years under traffic!



Final Conclusion



"The bitterness of poor quality remains long after the sweetness of low price is forgotten.“

Benjamin Franklin

Thank you for your attention!

J. Rettenmaier & Söhne GmbH & Co. KG

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