6th International Seminar on Asphalt pavements 2019 - 4th and 5th of April 2019, Opatija, Croatia

DETERMINING KEY INFLUENCE FACTORS OF A DURABLE ASPHALT REINFORCEMENT

Andreas Elsing
Dipl.-Ing., HUESKER Synthetic GmbH, Gescher, Germany

Agenda

- Introduction / Reflective cracking / asphalt reinforcement
- Fatique function
- Basic parameters
  - Long term bonding strength
  - Thermal expansion coefficient
- Conclusions

Road Rehabilitation

Fatigue cracking

Road Rehabilitation

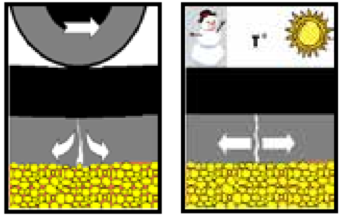
transverse cracks

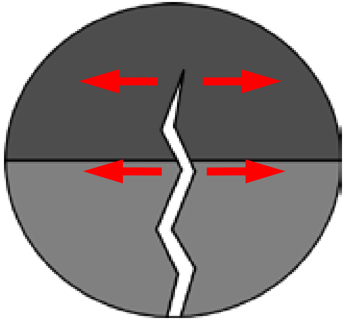
Road Rehabilitation

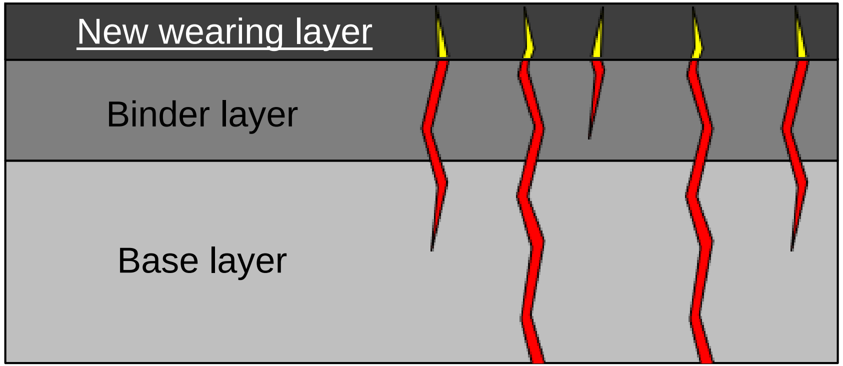
longitudinal cracks

Road Rehabilitation

Conventional rehabilitation







à Reflective cracking

Reasons for reflective cracking

Dynamic load

Shear action +

Bending action

Shear action -

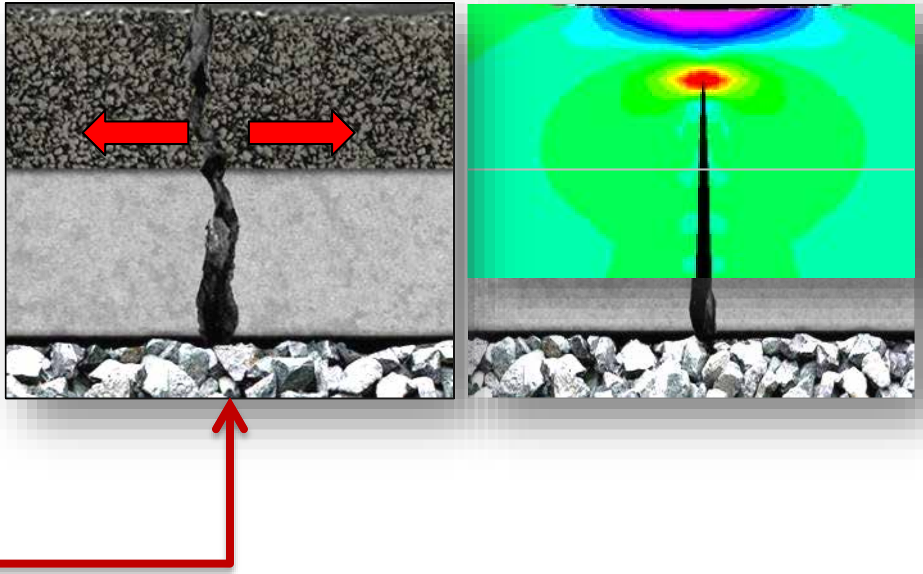
Reasons for reflective cracking

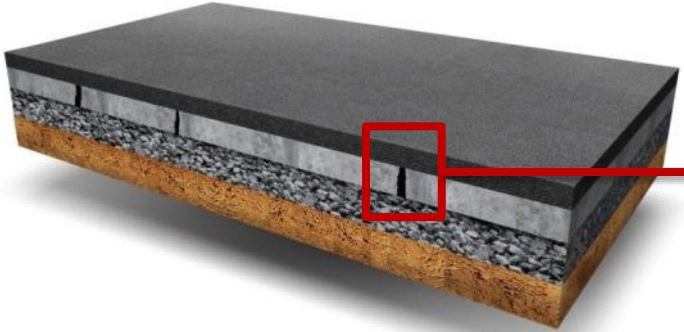
Temperature change

Reflective cracking

Crack growth

- into the new asphalt layer
- Due to high tension at crack tip

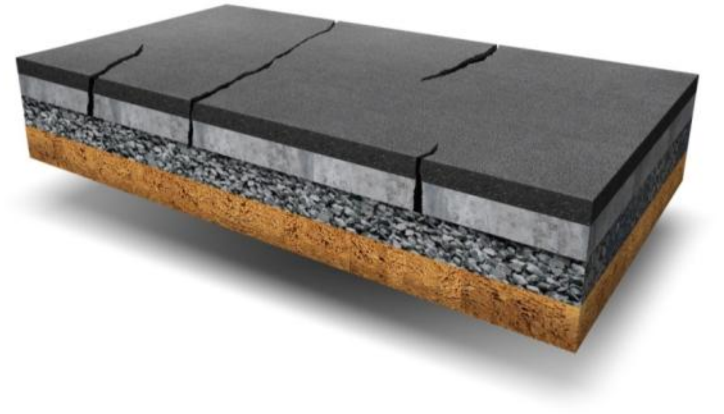




Source 1: Montestruque G. E., 2002, *Contribuição para a Ela-boração de Método de Projeto de Restauração de Pavimentos Asfálticos Utilizando Geossintéticos em Sistemas Anti-Reflexão de Trincas (Contribution to the preparation of a method of a project for rehabilitation of asphaltic pavements using geosynthetics on anti-reflective crack systems).* Doctor's Thesis, Technological Institute of Aeronautics, São José dos Campos, Brazil.

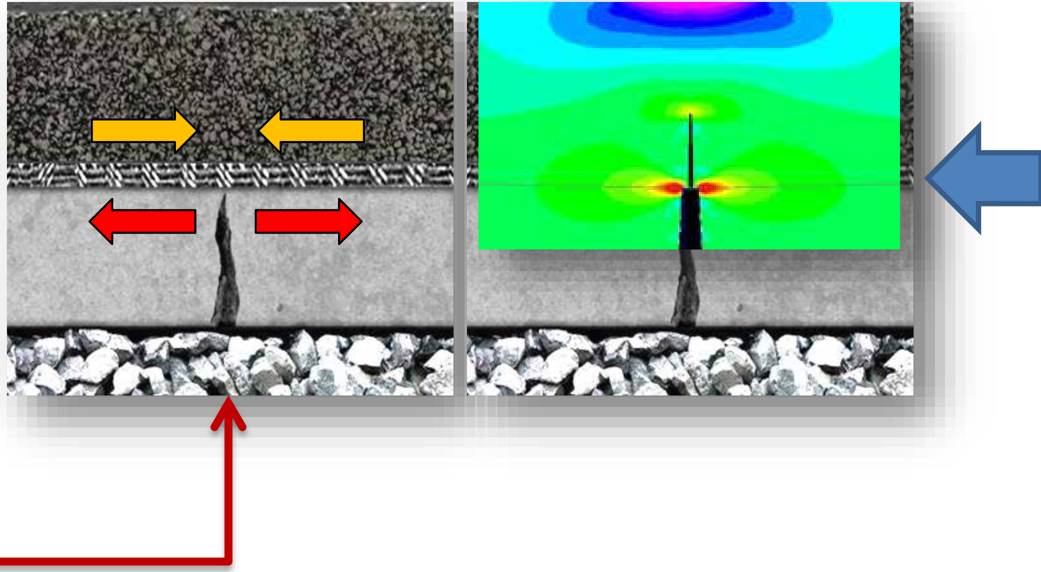
Reflective cracking facts

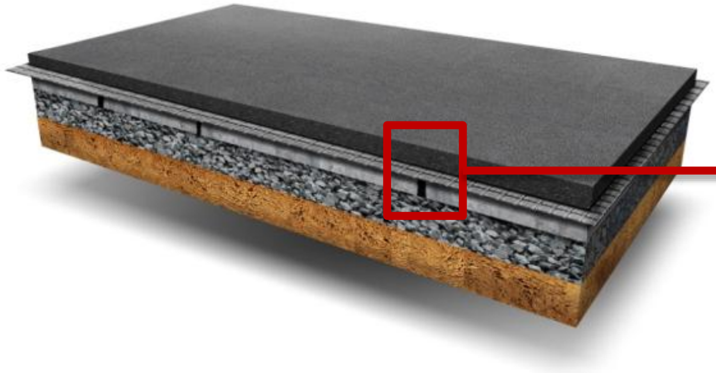
- Depending on the size and the load, a crack could grow between 1,0 and 2,5 cm per year.
- First reflective cracks could appear already after 1,5 – 4 years in a 4 cm wearing course.
- Therefore the control of reflective cracking is key for the durability of rehabilitated pavements.



Operating mode of reinforcement grids

Significantly reduced growth of reflective cracks, as the reinforcement grid absorbs and distributes the strain.





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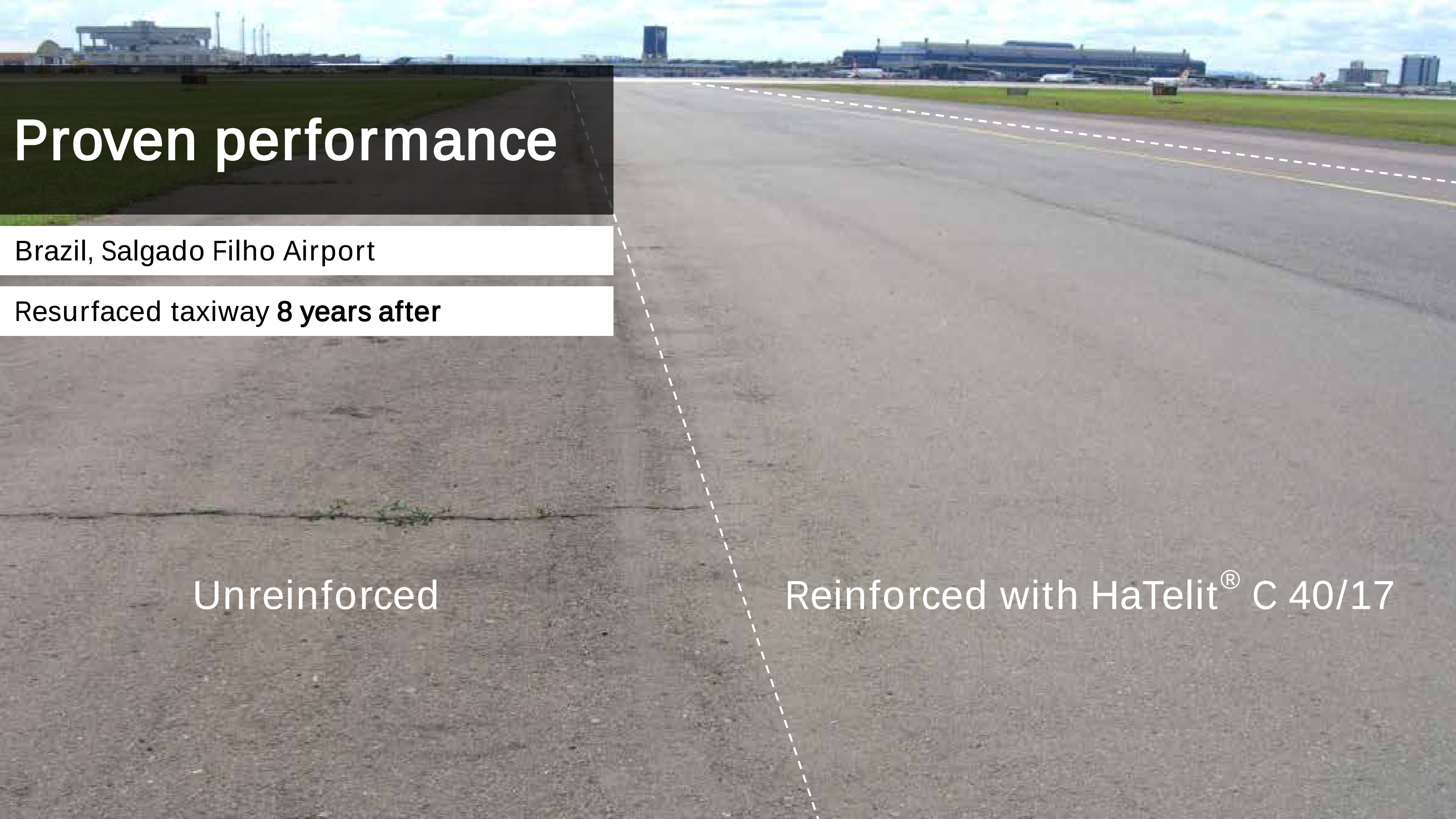
Proven performance

Brazil, Salgado Filho Airport

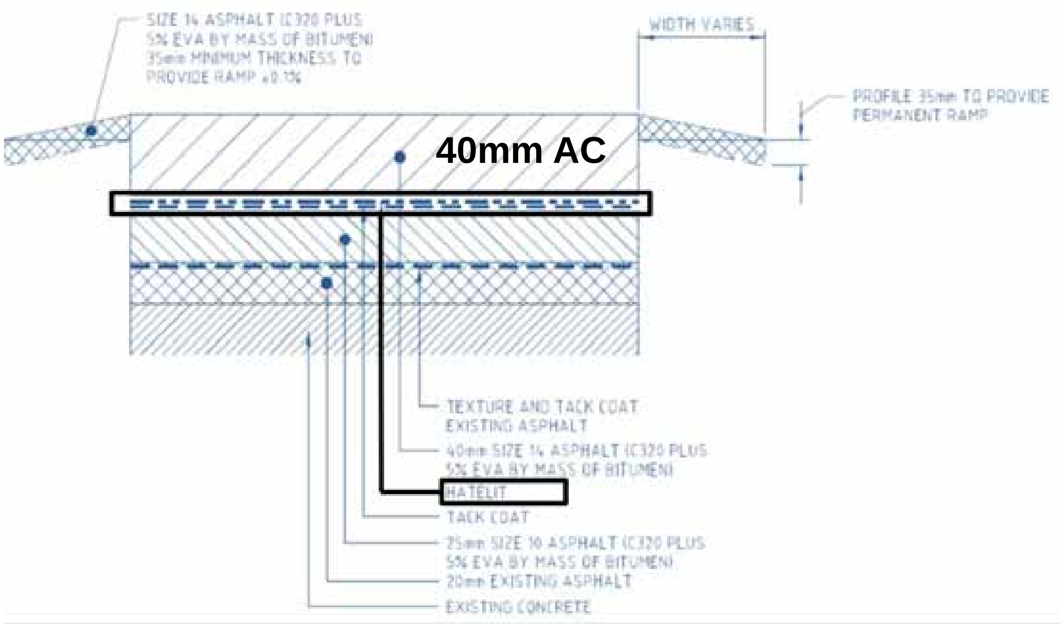
Resurfaced taxiway **8 years after**



Perth Airport | Australia

Before rehabilitation of airport runway 2009

Perth Airport, Australia: Runway Rehabilitation with HaTelit C



Runway 06 Pavement Rehabilitation

Source: Perth Airport, Airport Operations Management

Perth Airport, Australia: Runway Rehabilitation with HaTelit C

Source: Perth Airport, Airport Operations Management

Perth Airport | Australia

8 years after the rehabilitation with HaTelit C

Research

- Function / effect is well known and demonstrated but ….
- How does it work ?
- How can we calculate the effect ?

Fatigue cracking

Definition

"…fatigue cracking initiates at the bottom of the flexible layer due to repeated and excessive loading, and it is associated with the tensile strains at the bottom of the HMA layer"

(Huang, 1993)

Fatigue cracking

Equation

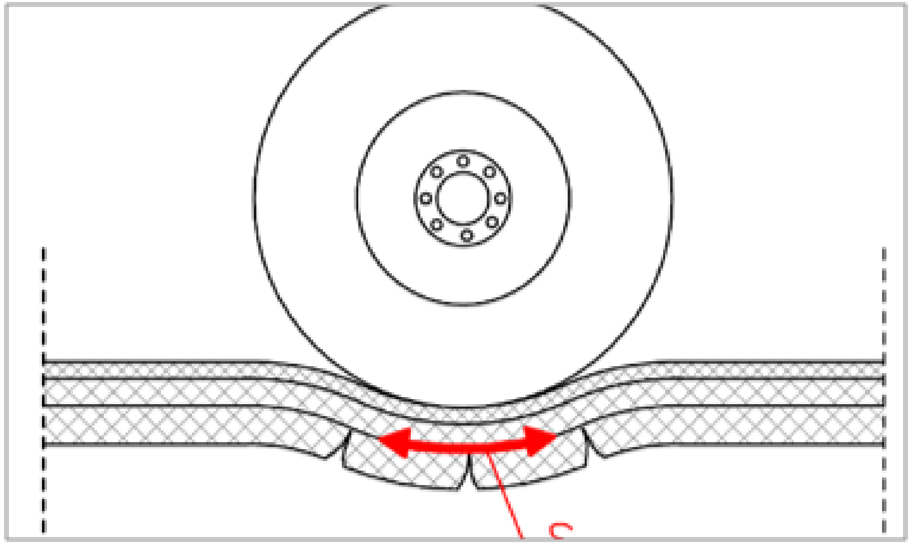
$$N_f = k_1 \, (1/\varepsilon_t)^{k_2}$$

N_f = allowable load repetitions of a pavement (until failure occurs)

k_1 = coefficient of fatigue

k_2 = exponent of the fatigue function

ε_t = elongation at the bottom of the asphalt layer [%]



Schematic illustration of the deformation below the asphalt layer (source: *igbv, Lüneburg*)

Fatigue cracking

Example

Reduction of elongation [%]	Elongation [ε_t]	Loading cycles [N_f]	Improvement factor
-	**ε =** 0,000100%	2.00×10^8	-
-5	**ε =** 0,000095%	2.99×10^8	1.5
-10	**ε =** 0,000090%	3.99×10^8	2.0
-20	**ε =** 0,000080%	6.10×10^8	3.0

Conclusion à A small reduction of the elongation below the asphalt layer has already a significant impact on the allowable loading cycles **!!!**

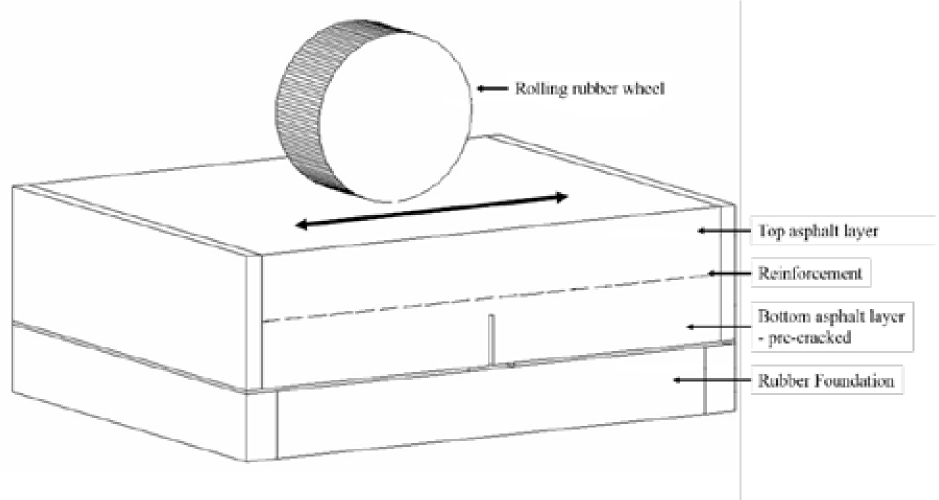
Scope of work

- Investigating the crack propagation under dynamic loads
- Comparison of unreinforced and reinforced specimen
- Recording the deformation

Master thesis

Test setup

- Modified rutting depth simulator
- Rubber foundation should simulate the base (unbound)
- Pre-cracked base course
  Reinforcement (HaTelit C40/17)
- Surface course (AC16)
- Rubber wheel (700 N)



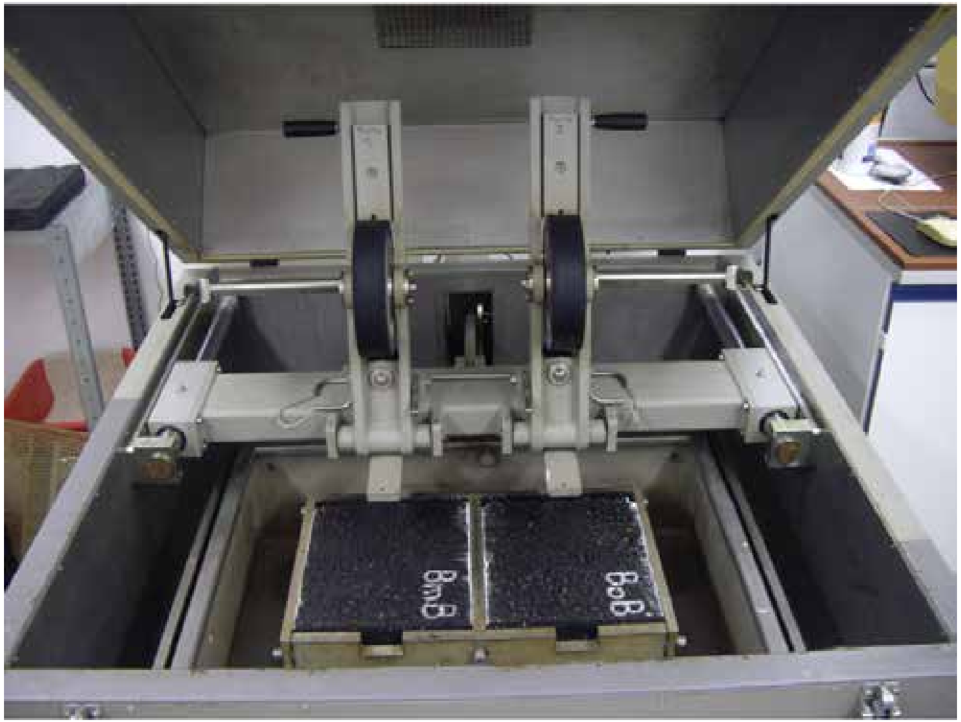
Schematic illustration of test setup
Source: *Diploma thesis Aron Höptner*

Test setup

Master thesis

Test execution

- Continues measurement of deformation
- 60.000 loading cycles

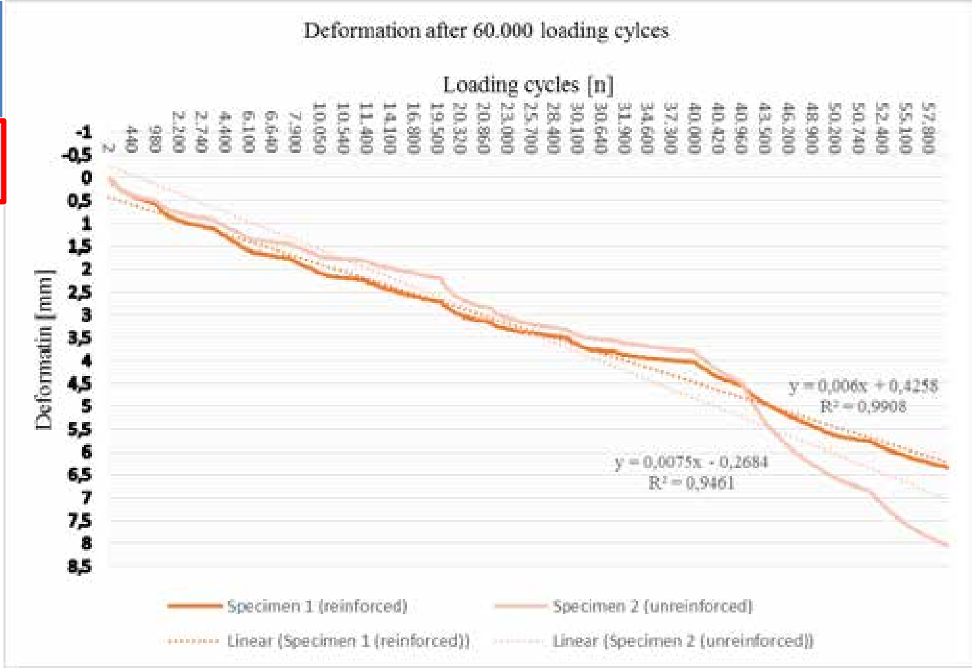


Master thesis

Results

Loading Cycles	Deformation specimen 1	Deformation specimen 2
60.000	6,34 mm	8,06 mm

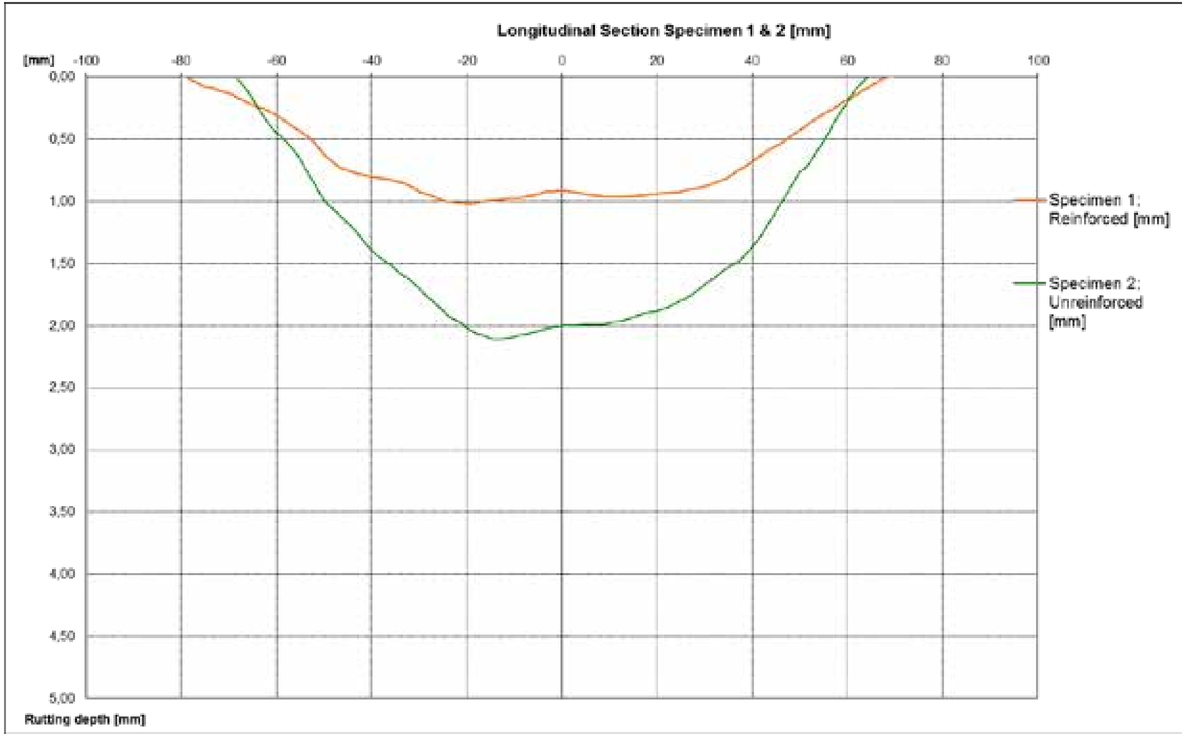
Reduction ~20%



Master thesis

Results (loading cycle 40.000 – 60.000)

- Reduction of the deformation by 50%
- > 4 times more allowable loading cycles



Demand: Good bond strength

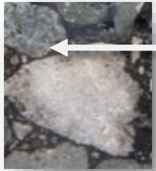
A good bond strength results from

Interlock

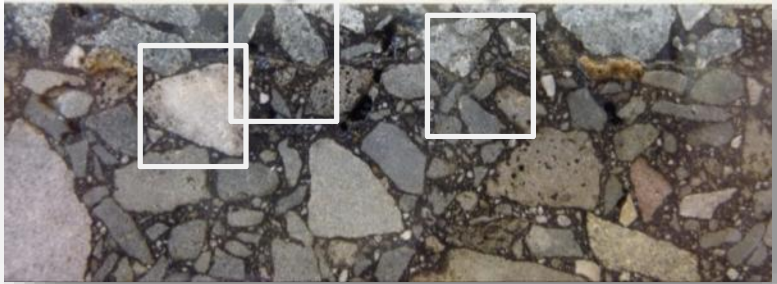
+

Adhesion

+



Friction



Demand: Good bond strength

A good asphalt reinforcement supports the bond strenght via

Interlock ↔ Mesh size

+

Adhesion ↔ Bituminous coating

+

Friction ↔ Mesh size and coating

Bonding strength

Based on the German guideline ZTV Asphalt-StB 07/13 the maximum shearing force within the testing procedure in accordance to Leutner should not fall below 15,0 kN (20 °C) in between asphalt binder course and surface layer.

temperature [°C]	without reinforcement		with reinforcement	
	mean value shearing force [kN]	mean value shearing distance [mm]	mean value shearing force [kN]	mean value shearing distance [mm]
20°C	26,1	3,9	24,9	3,8

Bonding strength not significantly reduced

Thermal expansion coefficient

Material combination	Thermal expansion coefficient	Ratio
Concrete / Steel	1.3×10^{-5} / 1.0×10^{-5} [1/K]	~1 : 1
Asphalt / Polyester	6.0×10^{-4} / 1.6×10^{-4} [1/K]	~1 : 4
Asphalt / Fiberglass	6.0×10^{-4} / 4.5×10^{-6} [1/K]	~1 : 130

KEY INFLUENCE FACTORS

- Tensile strength
- Bonding strength
- Thermal expansion coefficient
- Pull out stiffness
- Mobilisation of tensile strength in the interface

Research update

The University of Texas at Austin
Texas ScholarWorks
University of Texas Libraries

A Study on Geosynthetic-Reinforced Asphalt Systems

Luming Yang, M.S.E.

The University of Texas at Austin, 2018

Supervisor: Jorge G. Zornberg

Research update

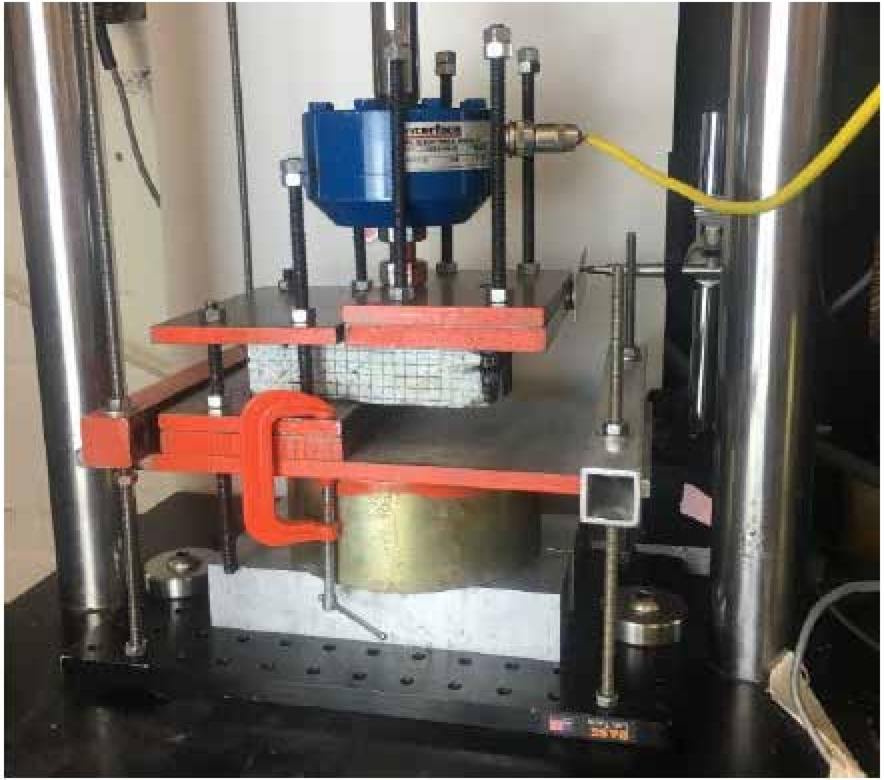


Figure 136. Finalized test setup for shear fatigue test

Research update

Conclusion:

“The low compatibility of the glass fiber reinforcement with the asphalt concrete resulted in the comparatively poorer performance than the polymer reinforced specimens”

Research update

“The performance of the glass fiber reinforced specimens was not as good as the polymer reinforced specimens in terms of retarding the load decline. This could be attributed to the varied compatibility of the reinforcement with the asphalt concrete.
The HaTelit® XP50 and HaTelit® C 40/17 consist of polymer fibers which are more compatible with the asphalt concrete in the stiffness of the materials than the glass fiber”

p. 224

Conclusions

If the asphalt reinforcement ….

- Straightforward and reliable installation
- Enables a good durable bonding strength
- Thermal expansion coefficient of the reinforcement close to asphalt
- High mobilization of tensile forces in the interface

Conclusions

Asphalt reinforcement is a cost effective rehabilitation method

- Longer life cycles
- Less maintanance costs
- Less construction works needed → less traffic jams

Questions ?


How
Why
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When
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