AAPA's 14th International Flexible Pavements Conference

A sustainable maintenance method for cracked pavements using polyester asphalt reinforcement. Increase pavement life, reduce maintenance and create sustainable pavements.

Christoph Hessing
Huesker Synthetic GmbH

150 YEARS

AAPA
AUSTRALIAN ASPHALT PAVEMENT ASSOCIATION

Asphalt reinforcement
- Basics -

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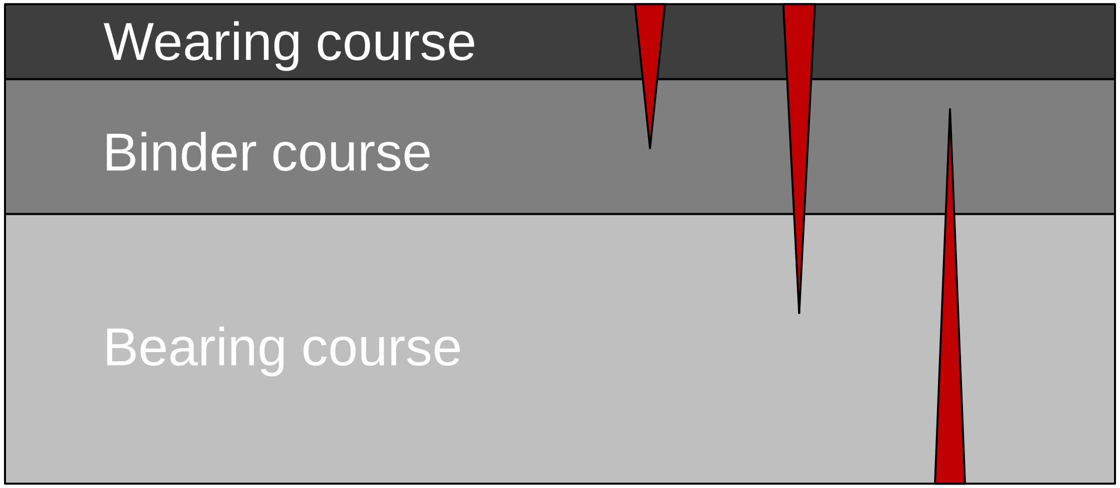
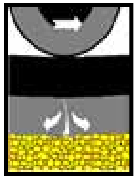
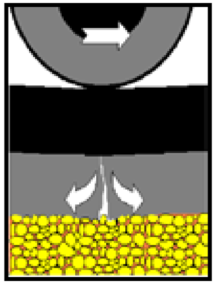
Cracks develop ...

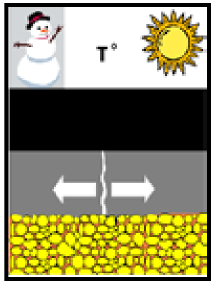


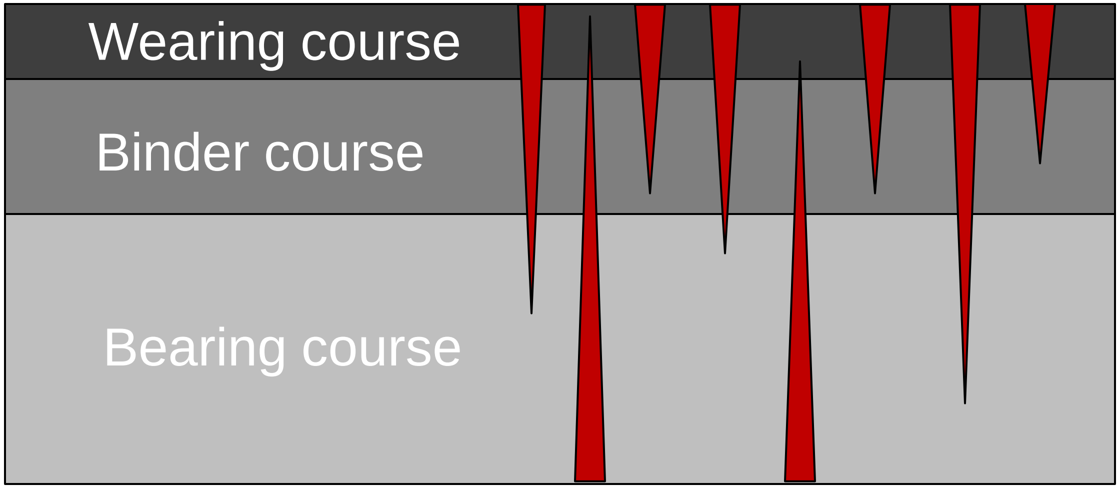
Crack development due to:

- **Aging of the Bitumen**
- **Temperature differences**
- **Dynamic loads (Traffic)**

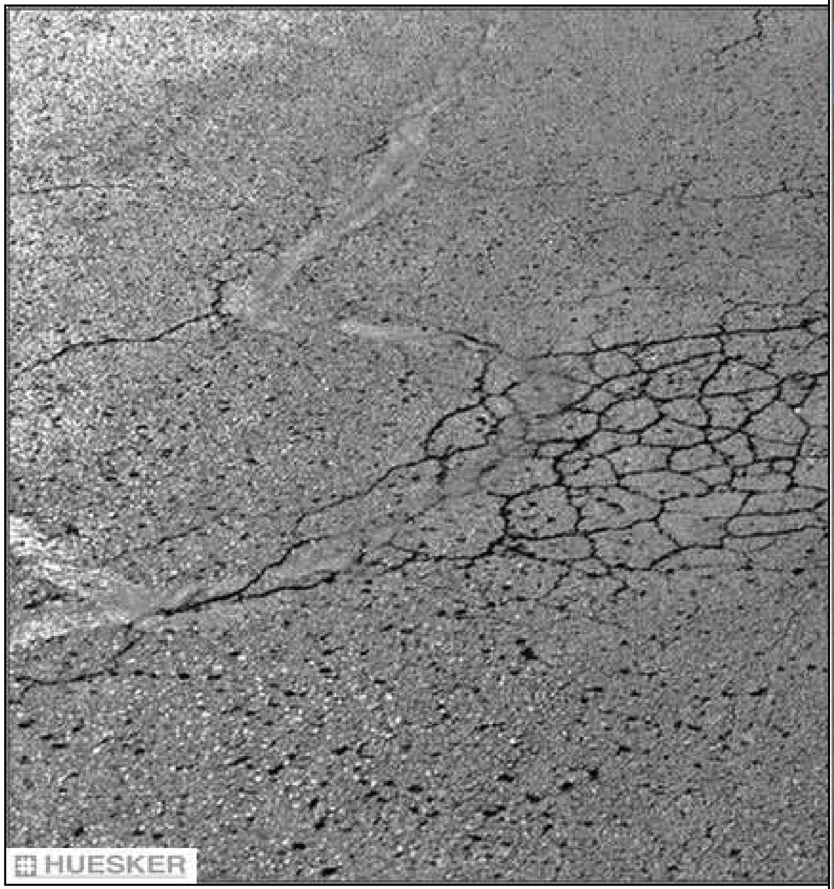








à situation after years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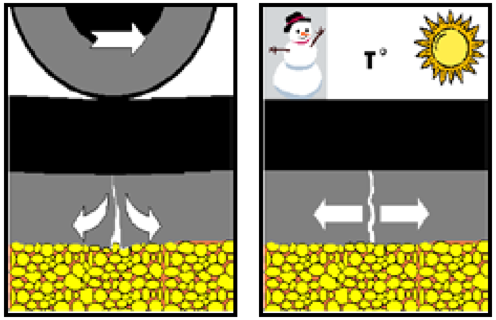
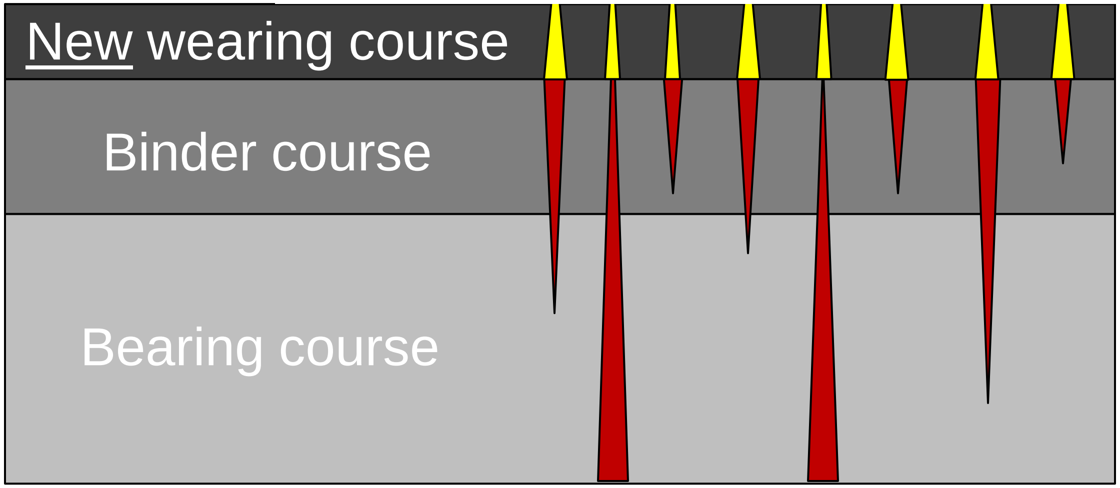
Option 1: conventional rehabilitation

Conventional rehabilitation





à **After short time: Reflective cracks**

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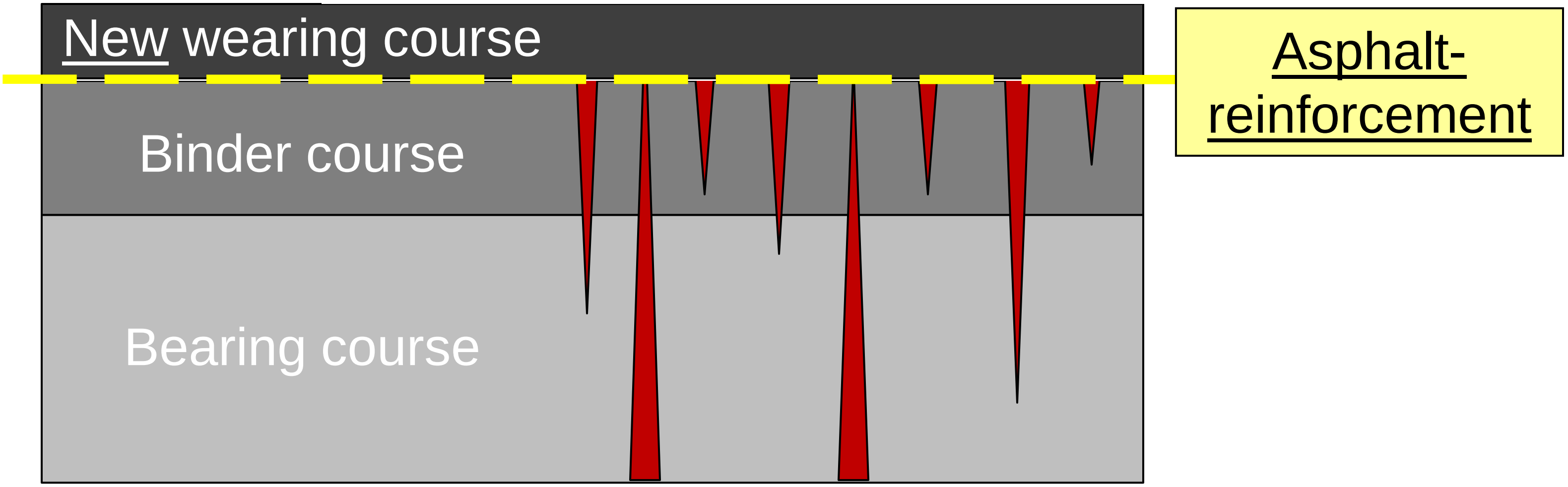
Rehabilitation



è **Durability of the pavement will be significantly increased!**

What is HaTelit® C 40/17

- Flexible reinforcement grid out of high modulus Polyester with a mesh size of 4 cm
- Ultralight non-woven serves as installation aid
- Grid is heat resistant up to 250°C
- Grid and non-woven are bituminous coated (excellent interlayer bonding)

Why Polyester?

- polyester is flexible and yet robust enough to withstand forces induced by supply traffic, installation of asphalt and compaction

- high modulus polyester is well compatible with the characteristics of the asphalt

- polyester can withstand cyclic loading much better than brittle materials such as glass

Why Polyester

… paving ...

Why Polyester

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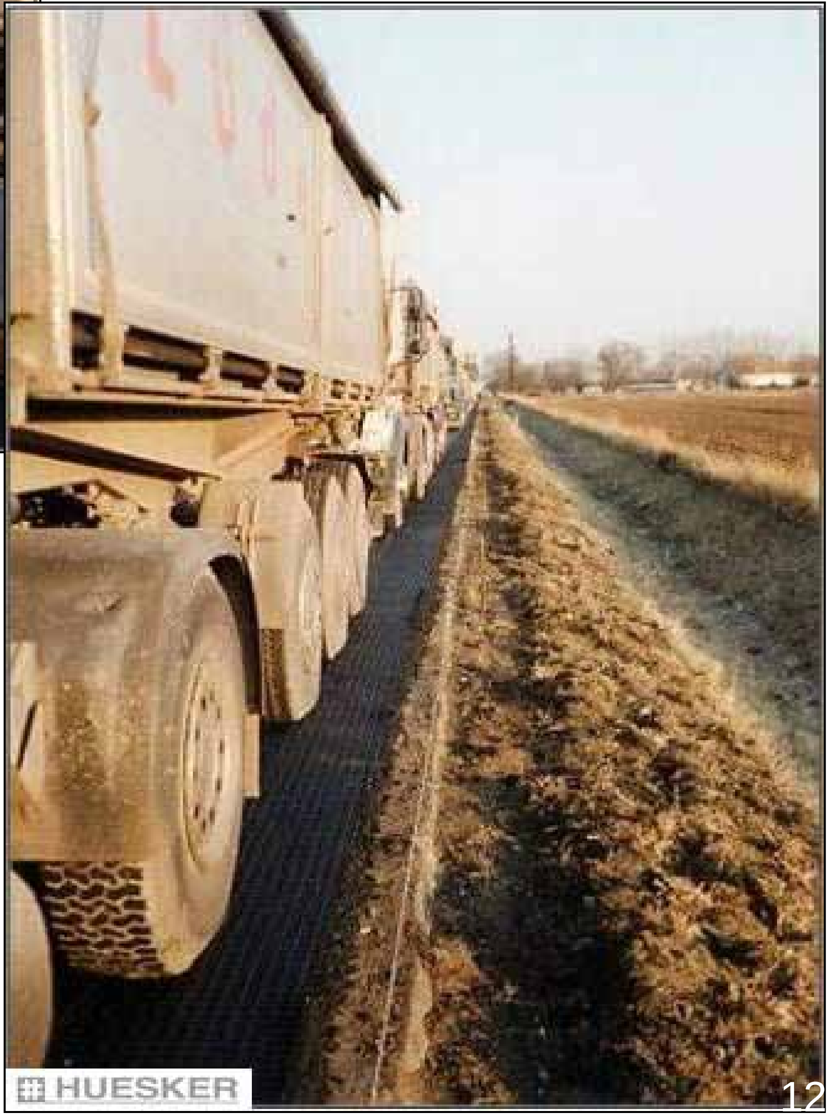

… traffic ...

… compaction ...

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Compatibility of asphalt and polyester

- Coefficient of thermal expansion -

1. Ratio of the coefficient of thermal expansion α [1/K]:

Example reinforced concrete:

α-Concrete: ~$1{,}3 \times 10^{-3}$
α-Steel: ~$1{,}0 \times 10^{-3}$ à Ratio: ~ 1 / 1

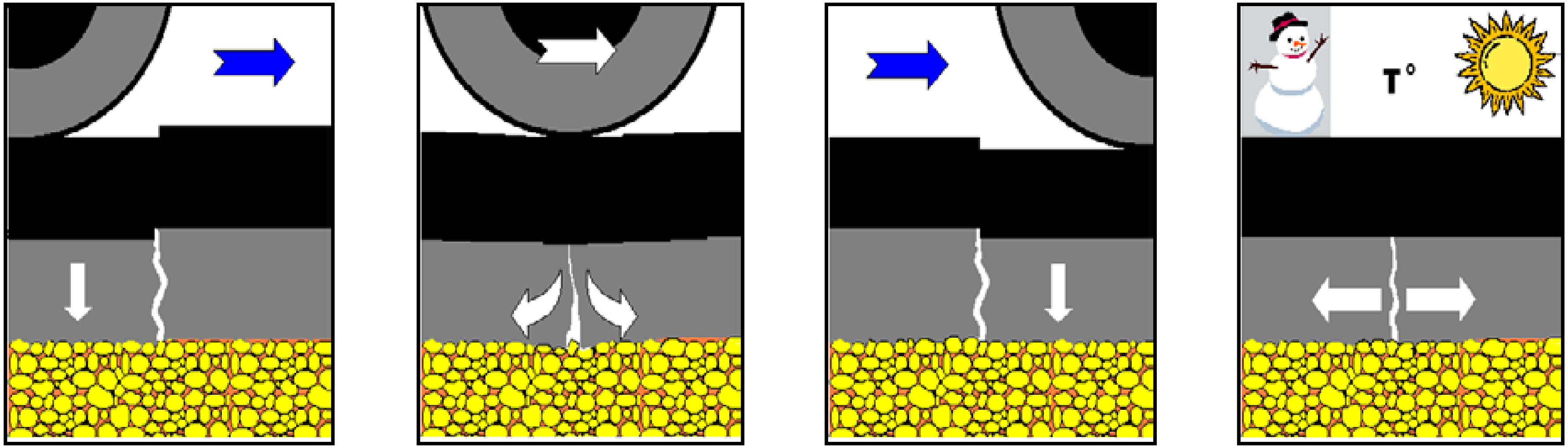
α-Asphalt: ~$6{,}0 \times 10^{-4}$
α-Polyester: ~$8{,}0 \times 10^{-5}$ à Ratio: ~ 1 / 7

α-Asphalt: ~$6{,}0 \times 10^{-4}$
α-Glassfibre: ~$4{,}5 \times 10^{-6}$ à Ratio: **~ 1 / 133**

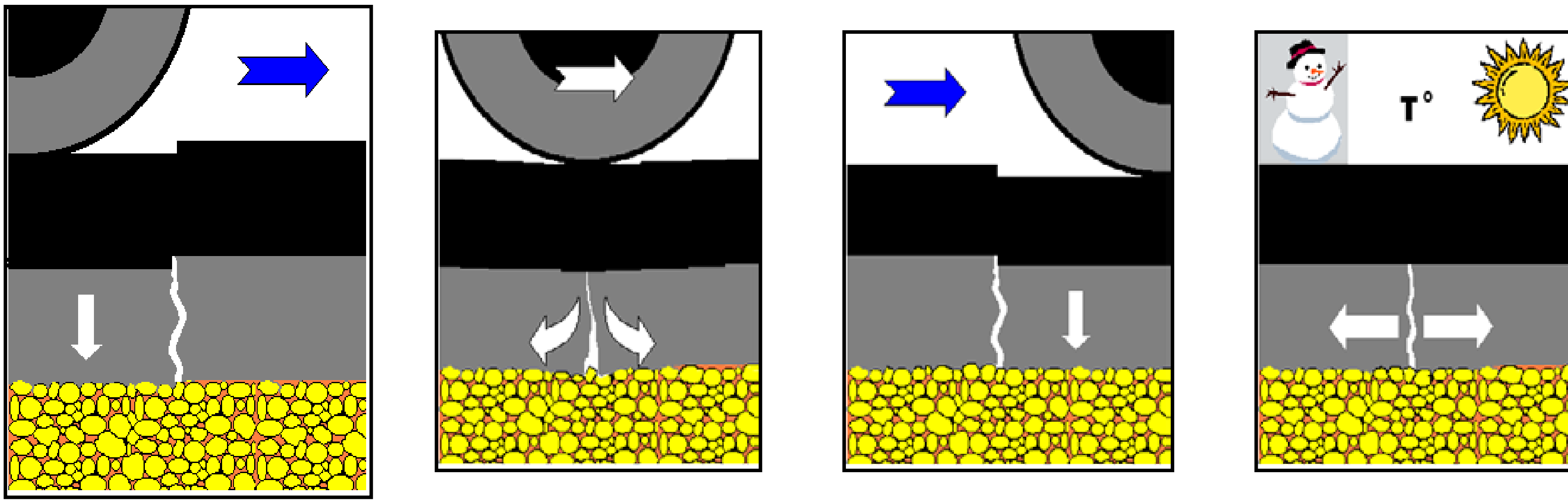
à **Polyester does not act as a foreign material!**

Results of Performance Tests

Critical load situations in a cracked pavement

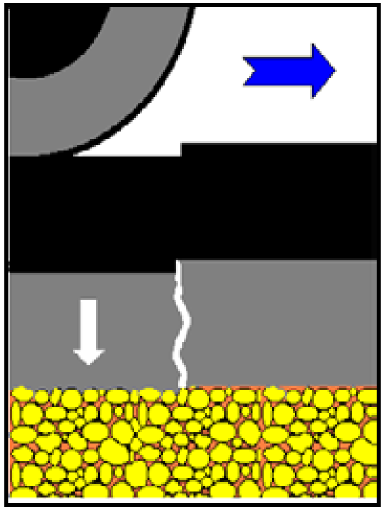


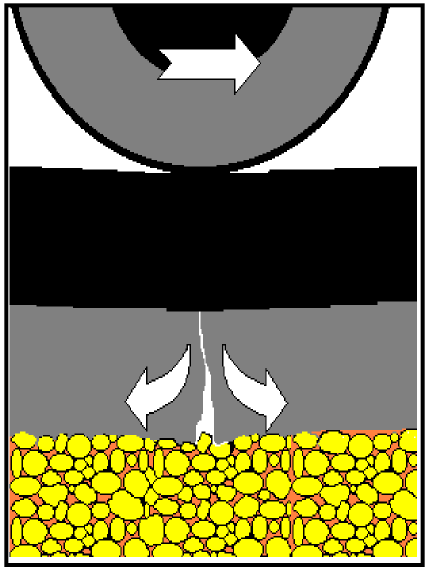
Critical load situations in a cracked pavement



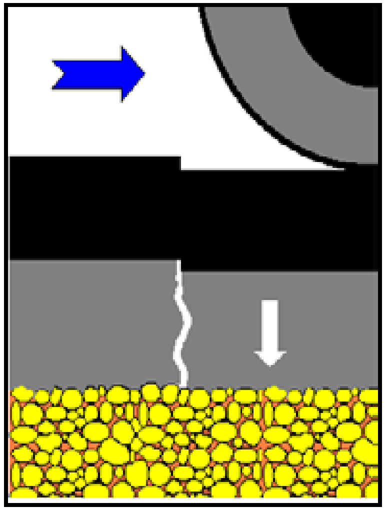
Shear mode (+)

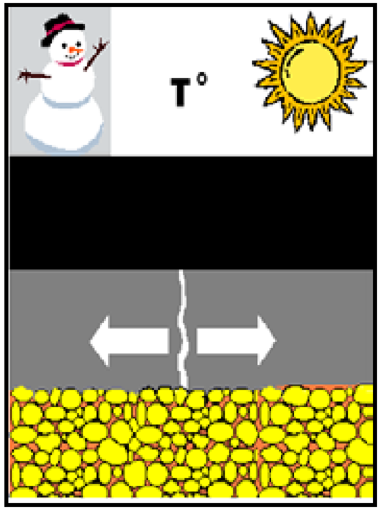
Critical load situations in a cracked pavement



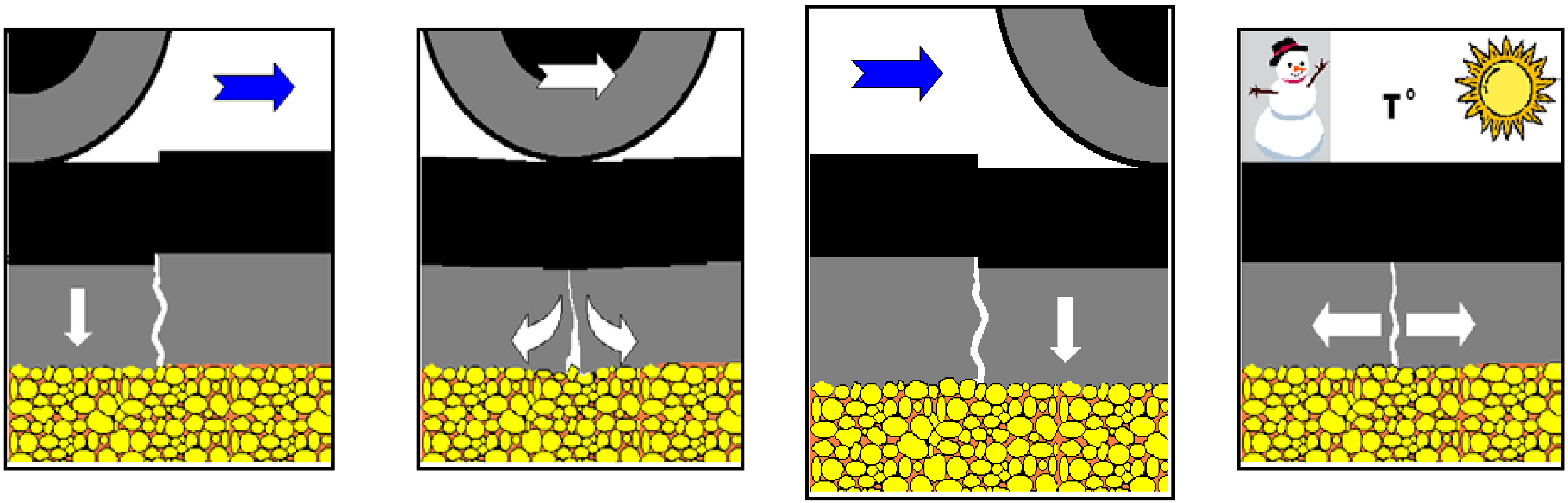


Bending mode



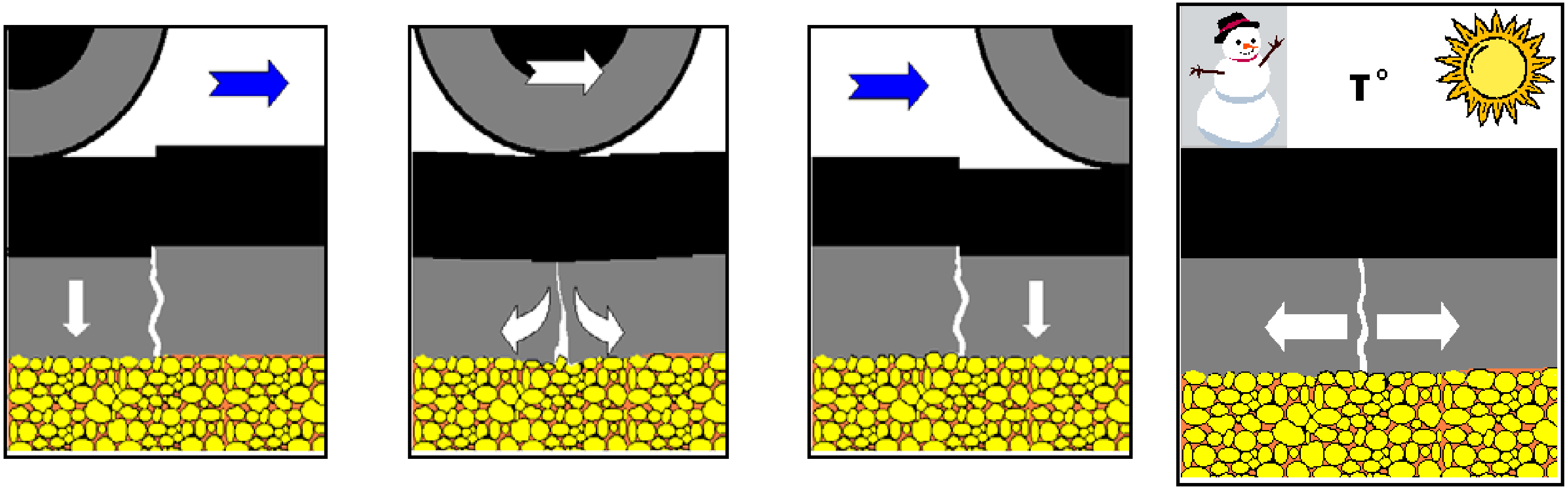


Critical load situations in a cracked pavement



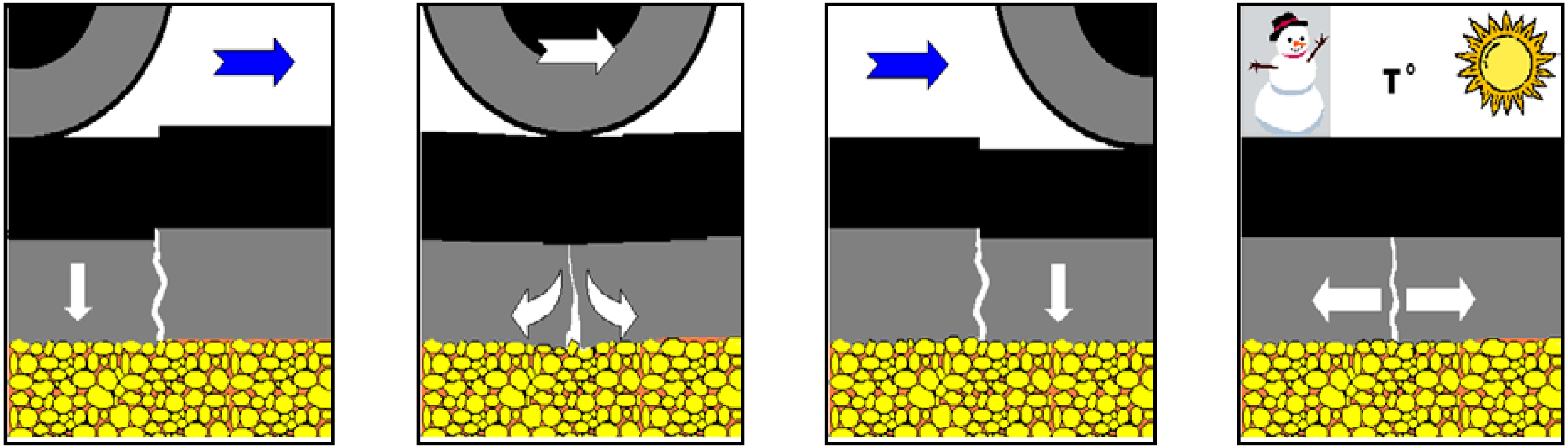
Shear mode (-)

Critical load situations in a cracked pavement



Temperature

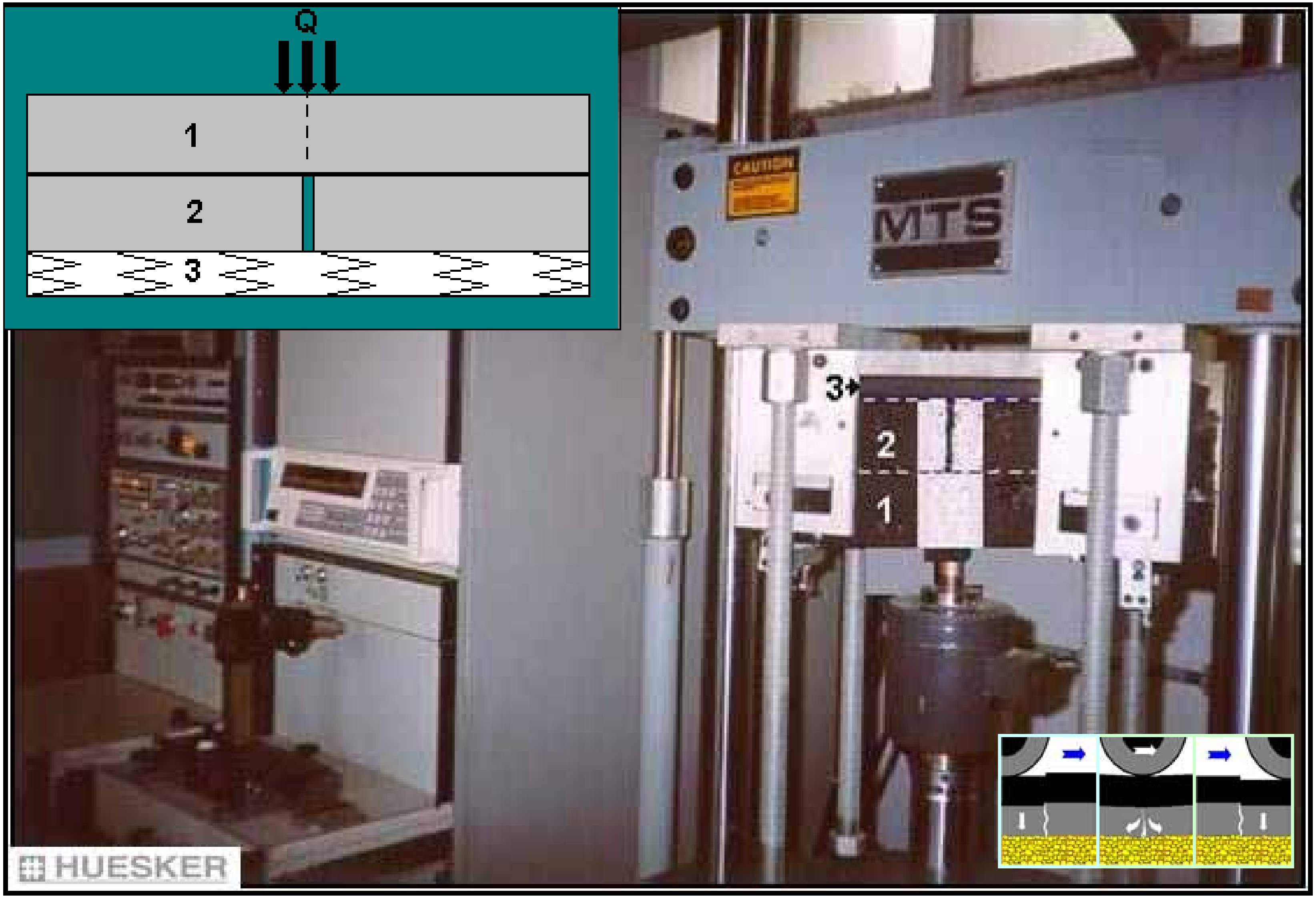
Critical load situations in a cracked pavement

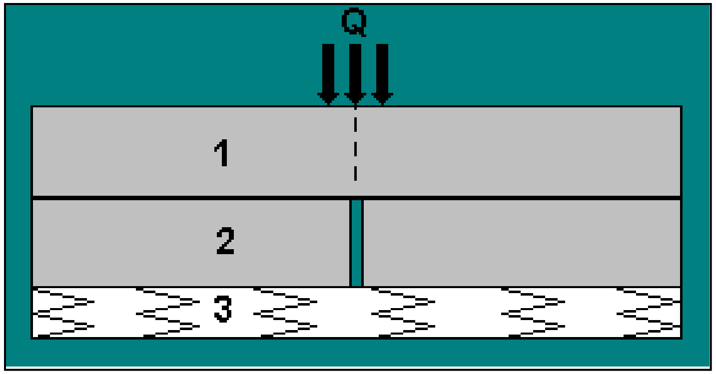


Dynamic fatigue tests

Tests to determine the effect of HaTelit® in anti reflective cracking applications in Asphalt overlays

Test set up, dynamic fatigue

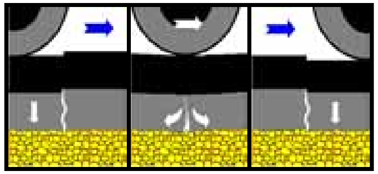




(1) Overlay

(2) blocks with opening

(3) Elastic base (rubber)



- Material: HaTelit® C 40/17
- Precrack: 3 mm, 6mm, 9 mm
- HaTelit position: directly above the crack tip
- Load position: Bending and shear mode
- Contact pressure: 560 kN/m²


Typical crack
(without reinforcement)
N=79,884
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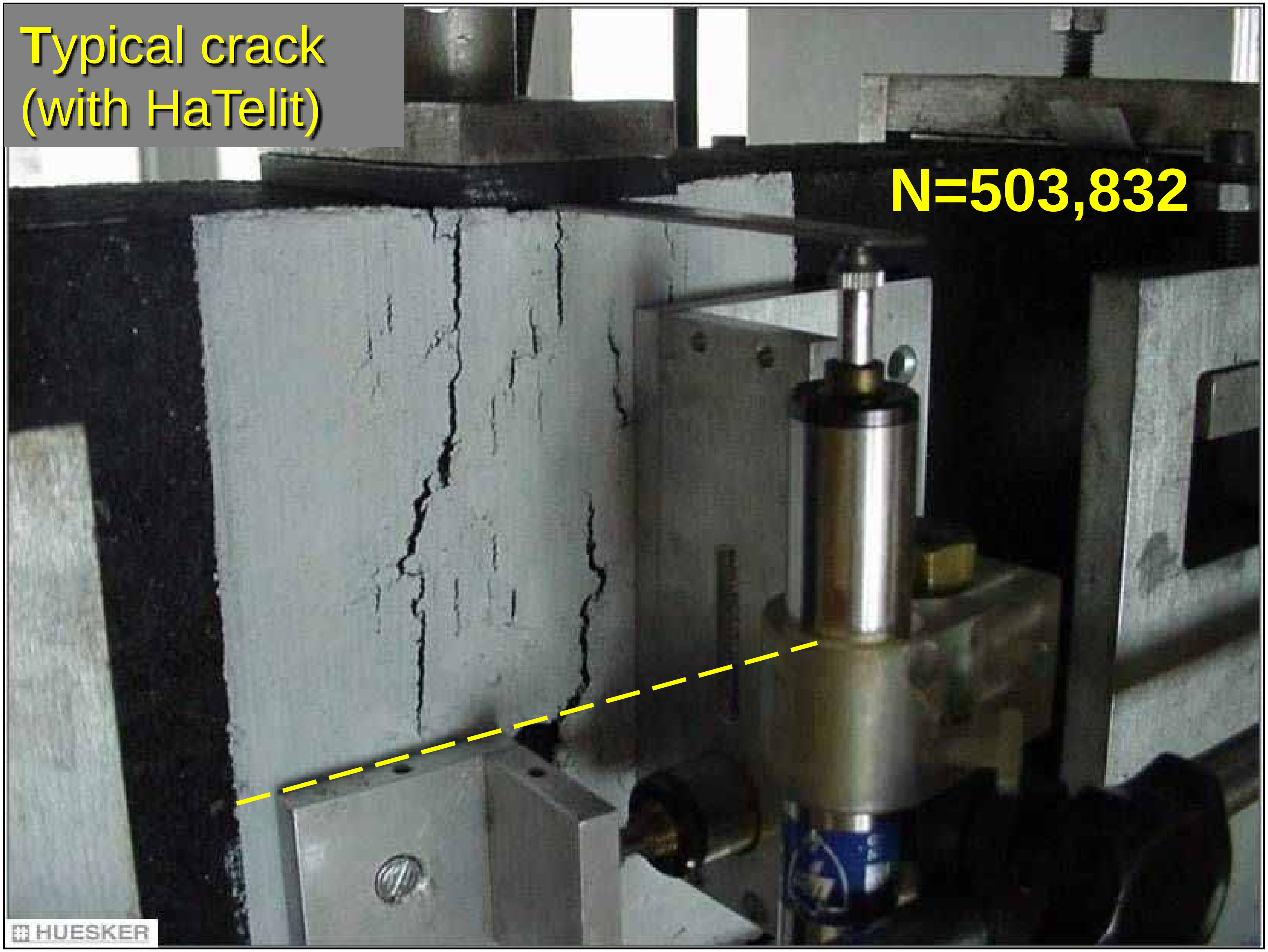
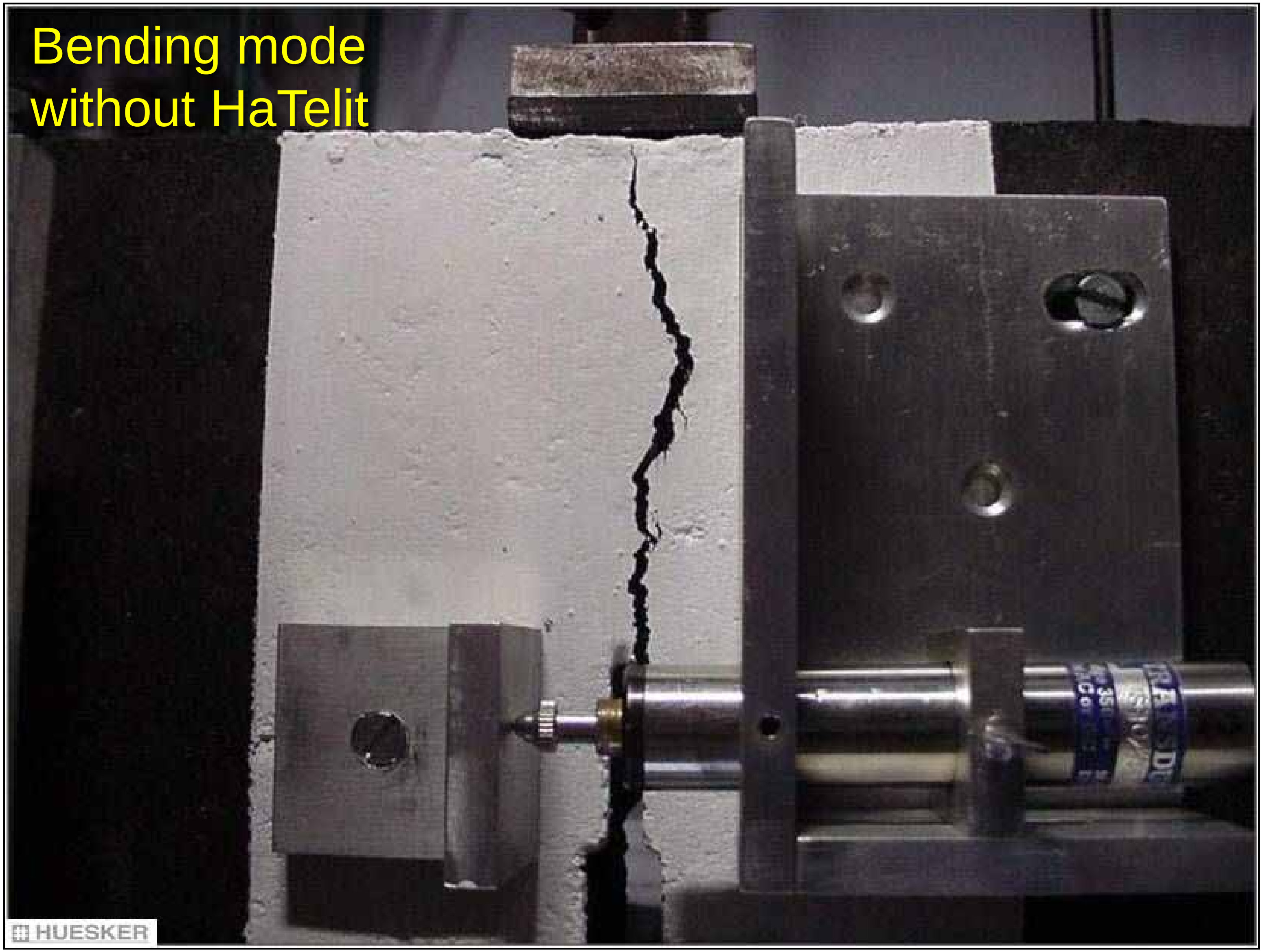

Typical crack
(with HaTelit)
N=503,832
HUESKER


Bending mode
without HaTelit
HUESKER


Bending mode
with HaTelit
HUESKER

"Improvement factor"

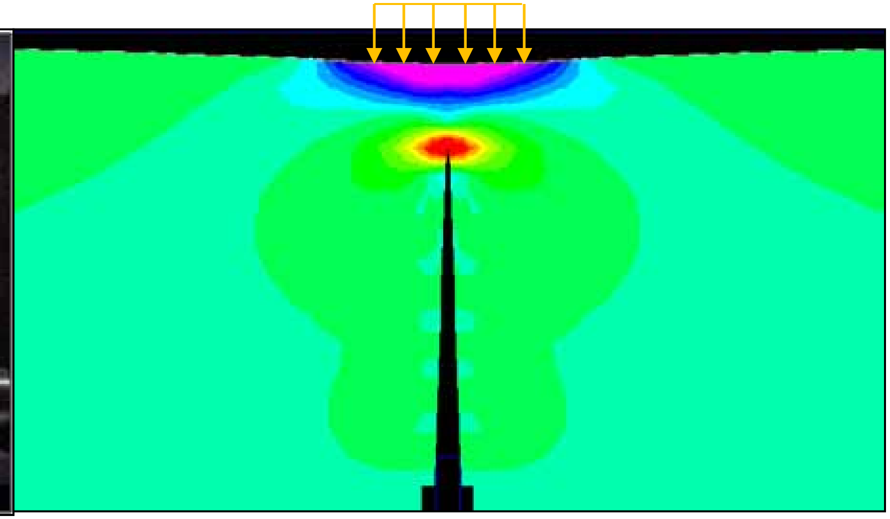
$$Vf = N_{f(\text{with Hatelit})} / N_{f(\text{without Hatelit})}$$

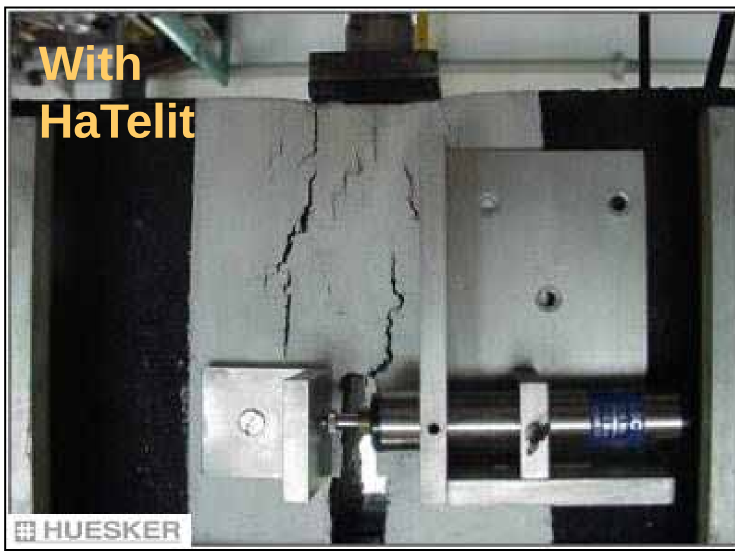
$$N_f = \frac{1}{c_{f1}}$$

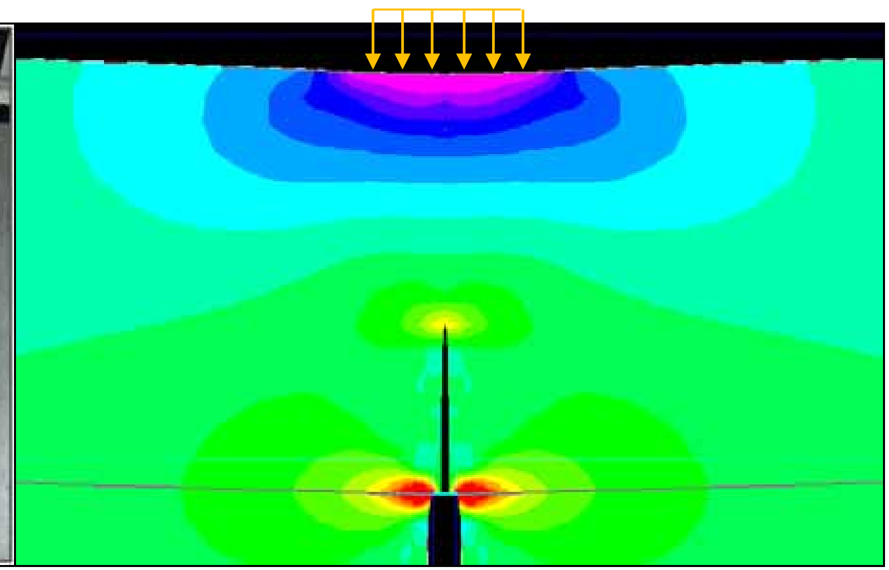
$$c_{f1} = \frac{1}{N_{f\ (B)}} + \frac{2}{N_{f\ (S)}}$$

$$4.60 < Vf < 6.14$$

Research results and FEM Simulation







Proof of the effectiveness

by project experience

Project Report

Rehabilitation of Corso Giovanni Agnelli, Torino - Italy

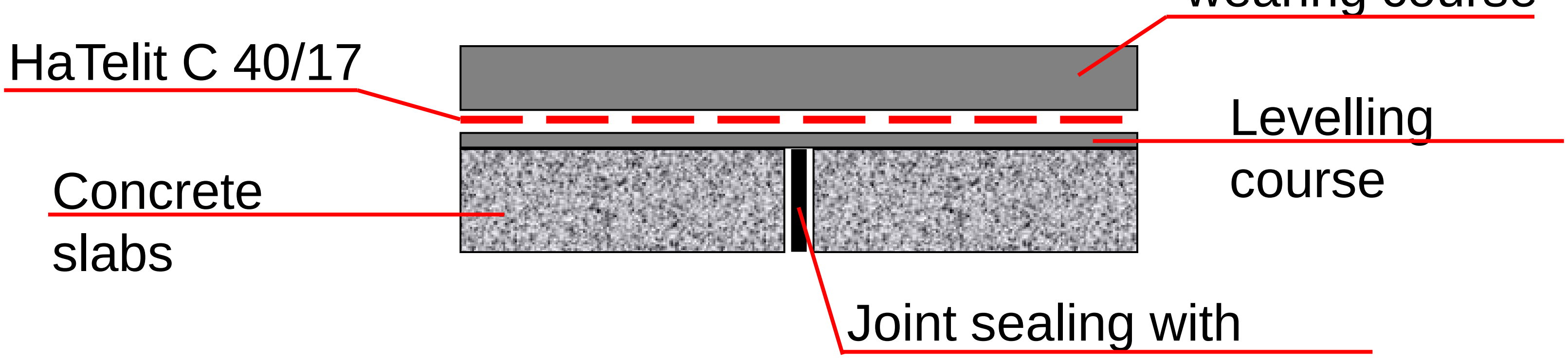
Background:

- 2005 parts of the Corso Giovanni Agnelli in Torino had to be rehabilitated
- Existing pavement: Asphalt layer on concrete slabs

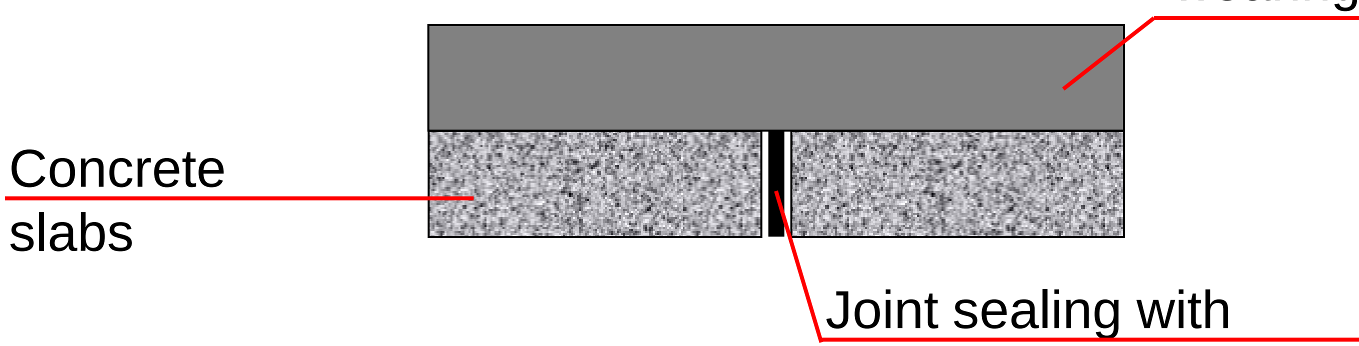
Corso Giovanni Agnelli, Torino

Design

Section 1:



Section 2:



June 2005:
Rehabilitation of Section 1

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June 2005: Installation of HaTelit®

Corso Giovanni Agnelli, Torino

June 2005: Installation of 4 cm asphalt wearing course

July 2005, two weeks later:

Rehabilitation of Section 2

Section 2: Installation of only 5 cm asphalt wearing course

May 2006,
Ten month after the rehabilitation

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May 2006: Cracks start to develop in unreinforced section

Condition in July 2009,

4 years after the rehabilitation

Section 1: July 2009 - 4 years after rehabilitation

Corso Giovanni Agnelli, Torino

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Section 1: July 2009 - still in excellent condition - no cracks

Section 2: July 2009 - 4 years after rehabilitation

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August 2010 - 5 years after rehabilitation

Severe cracking and damages in the unreinforced section è full overlay replacement done in August 2010.

Note: First cracks reflected already after 1 year

Reinforced section:

Excellent condition after 5 years !!!

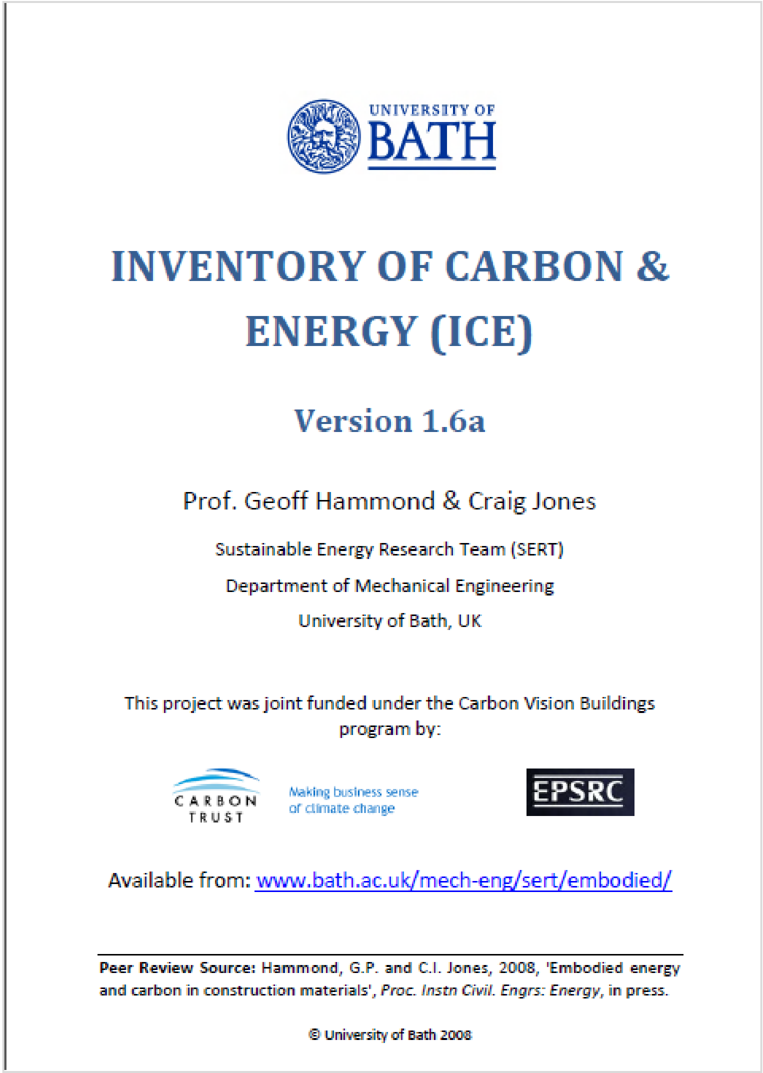
The research and project examples presented confirm that the lifetime of the reinforced pavements can be extended by a factor of 3 to 4

COMPARISON OF EMBODIED ENGERGY FOR REINFORCED AND UNREINFORCED ASPHALT OVERLAYS

DATA SOURCE

Inventory of Carbon & Energy (ICE) by the University of Bath, UK

Database which is continuously updated for embodied energy and carbon coefficients for building materials.


UNIVERSITY OF BATH

INVENTORY OF CARBON & ENERGY (ICE)

Version 1.6a

Prof. Geoff Hammond & Craig Jones

Sustainable Energy Research Team (SERT)

Department of Mechanical Engineering

University of Bath, UK

This project was joint funded under the Carbon Vision Buildings program by:

CARBON TRUST Making business sense of climate change EPSRC

Available from: www.bath.ac.uk/mech-eng/sert/embodied/

Peer Review Source: Hammond, G.P. and C.I. Jones, 2008, 'Embodied energy and carbon in construction materials', *Proc. Instn Civil. Engrs: Energy*, in press.

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Examples of Embodied Carbon Dioxide ECO_2

Material	kg ECO_2 / kg of material	Note
Aggregate	0.0052	gravel or crushed rock
Aluminium	9.16	-
Asphalt	0.076	6% binder content
Bitumen	0.55	-
Cement	0.74	UK weighted average
Concrete 16/20	0.10	unreinforced
Reinforced Concrete RC 40/50	0.188	high strength applications / precast
PVC General	3.10	-
Polyester	1.93	derived from HDPE
Steel	1.46	average UK recycled content
Steel	2.89	Virigin steel
Source: ICE Inventory of Carbon & Energy V2.0		

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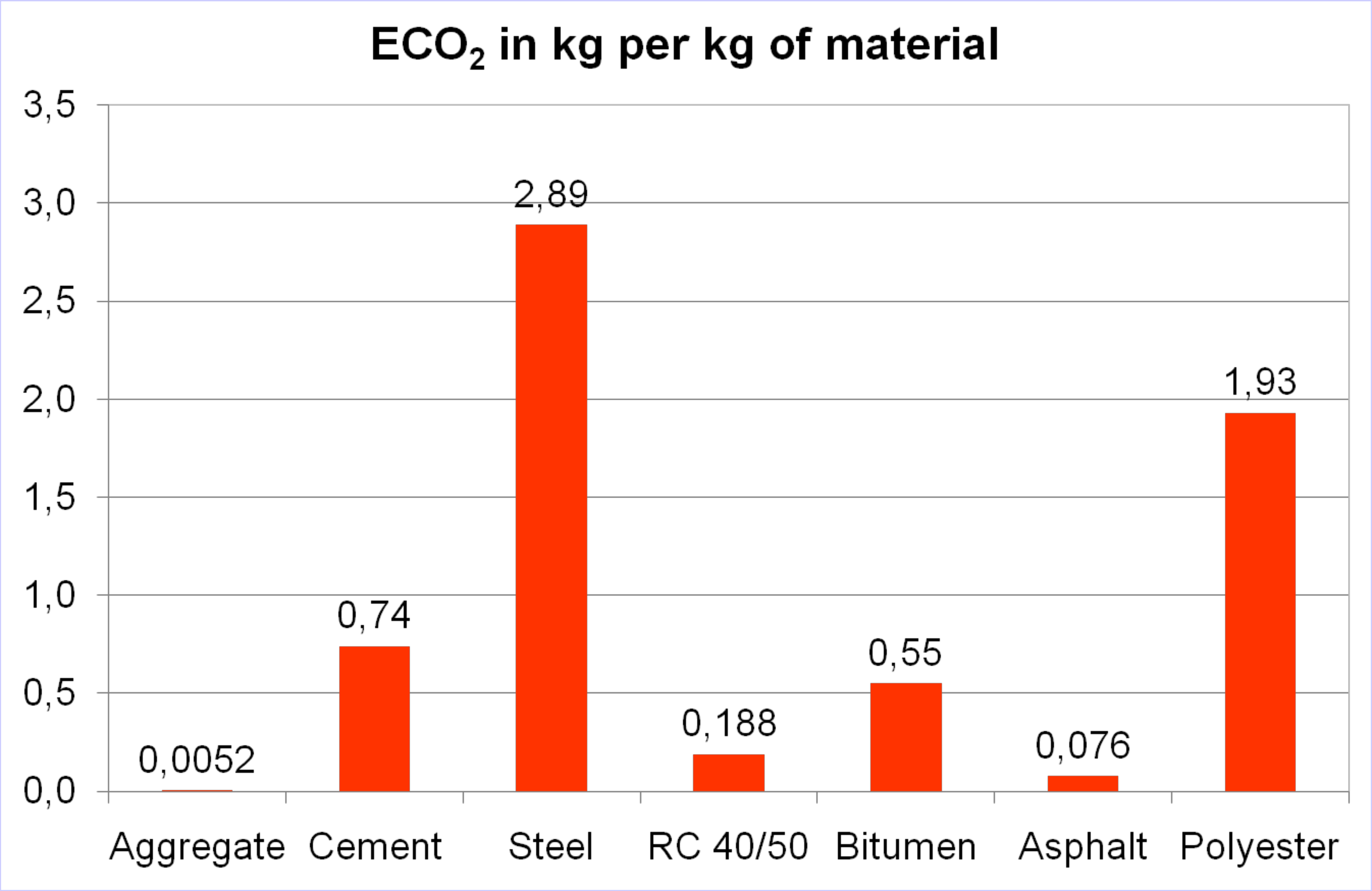
ECO$_2$ in kg per kg of material
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
0,0052
0,74
2,89
0,188
0,55
0,076
1,93
Aggregate
Cement
Steel
RC 40/50
Bitumen
Asphalt
Polyester

Comparative calculation of ECO_2 for reinforced and unreinforced asphalt overlays based on materials used

Material	Material consumption	kg embodied CO_2 per kg of material	embodied CO_2 in kg / m²	
			unreinforced	HaTelit® reinforced

Conclusions

- PES asphalt reinforcement grids with bituminous coating significantly delay reflective cracking
- Project experience and research presented shows that pavement life can be increased by a factor of 3 - 4 by using HaTelit® asphalt reinforcement
- Unreinforced pavement rehabilitation:
  1.93 kg ECO_2 / m² / year design life
- HaTelit® reinforced pavement rehabilitation:
  0.71 kg ECO_2 / m² / year design life

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Conclusions

- Significant saving in Embodied Carbon Dioxide of 63 % based on material consumption

- The application of HaTelit® asphalt reinforcement saves resources by extending pavement life and thus is a key to sustainable maintenance methods