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Evaluation of the Mechanical Performance Recovering in Asphalt Roads after Healing Process by Induction Heating

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Materials Science & Technology

Evaluation of the Mechanical Performance Recovering in Asphalt Roads after Healing Process by Induction Heating



Outline

- Introduction on Induction Heating
- Experimental Setup
- Results
- Conclusions



Healing

Definition of Healing:

Recovery of original material constitution after damage.

- Healing \neq **Upgrading**: Change material constitution to the better,
- Healing \neq **Rejuvenating**: Restore original material constitution after aging

Self Healing:

Healing through **self-activated** intrinsic healing potential

- The repair is smart and autonomous
- Cheap

Goal for Asphalt Pavements:

- Repair of **100%** damage (loss of adhesion, cohesion)
- For an **infinite number** of time
- **Affordable** and easy to apply

Stimulated Healing:

Healing through **externally activated** intrinsic healing potential

- Needs an external stimulus
- Expensive

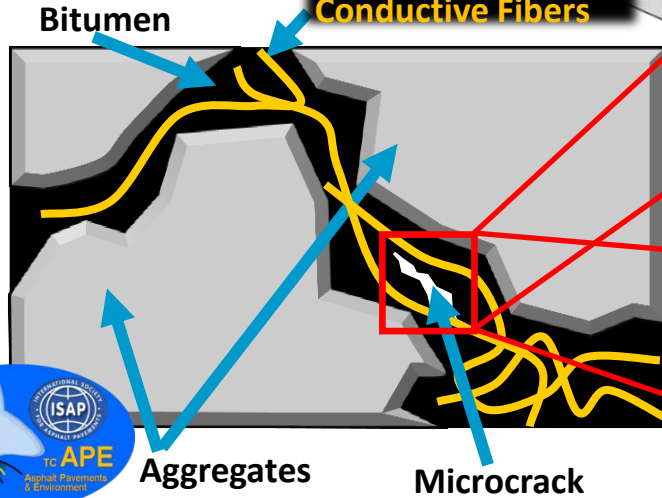
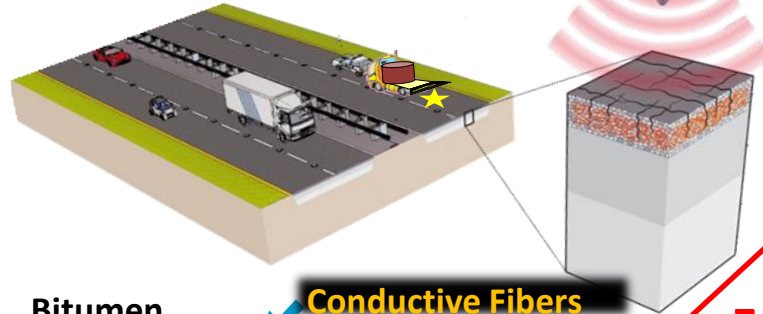
Thermal crack healing with induction



Introduction

Induction Heating Approach

Vision:



Zoom

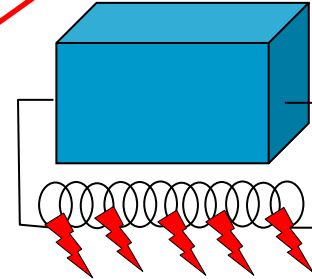


Conductive Fibers

Opening of Microcracks

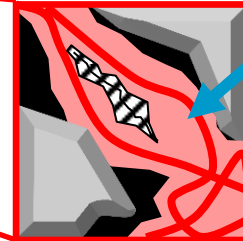
+

Induction Heating



Melted Bitumen

Zoom

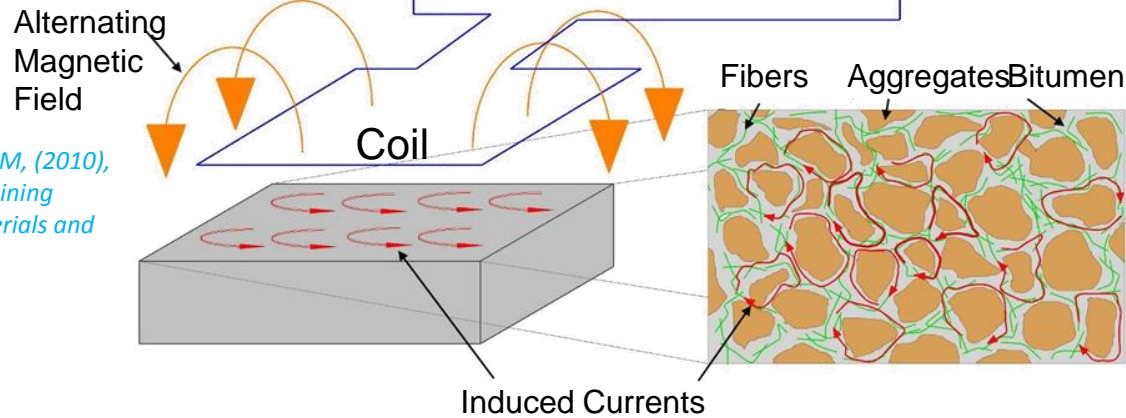
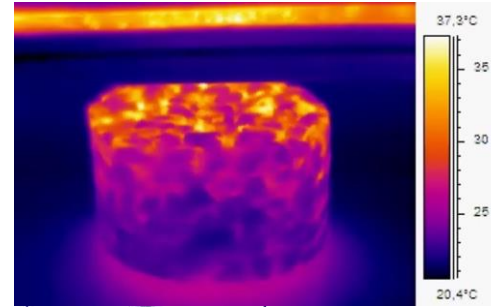
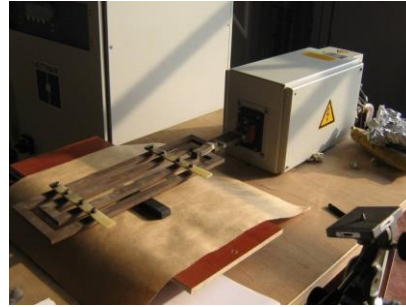
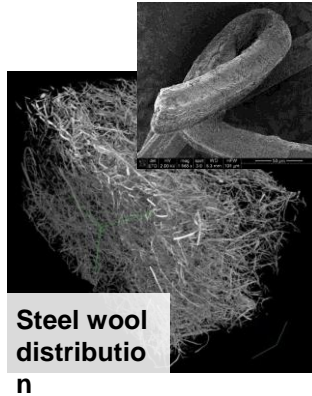


Crack closed



Introduction

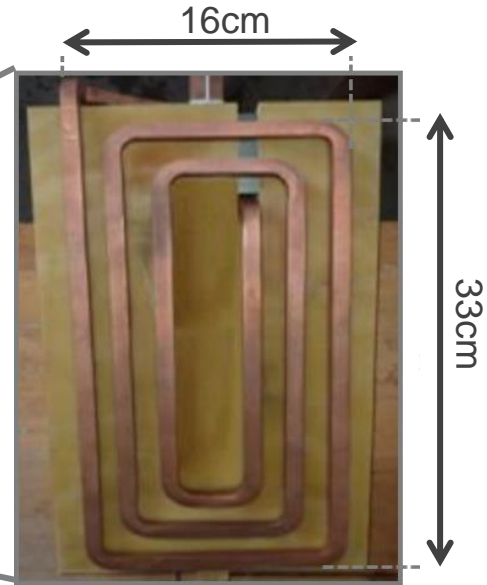
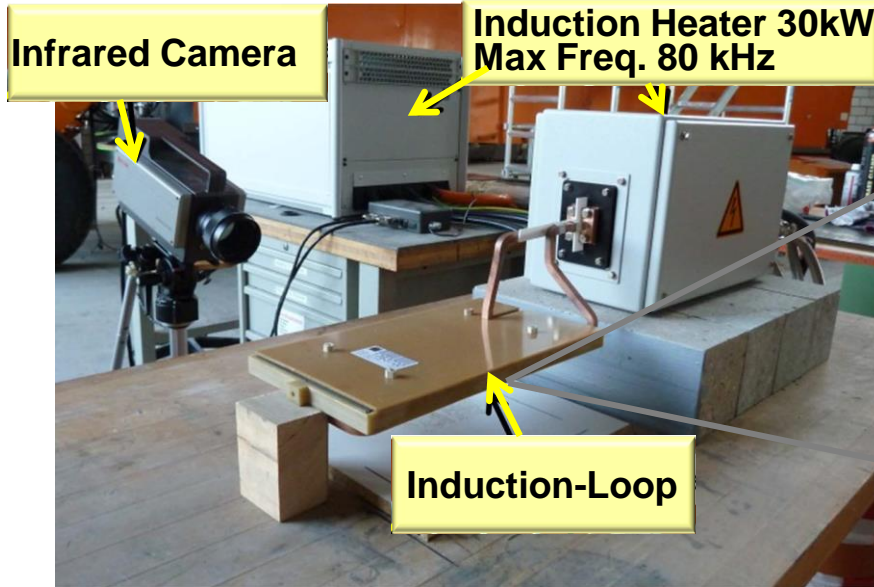
Induction Heating



García A, Schlangen E, van de Ven M, (2010), "Induction heating of mastic containing conductive fibers and fillers", *Materials and Structures* 44, 2, 499-508.



Induction Heating Device



Experimental Setup

Materials

Asphalt Mixture **AC8 + 14%wt. iron particles** (0.6-1.0 mm)

BAV Volketswil

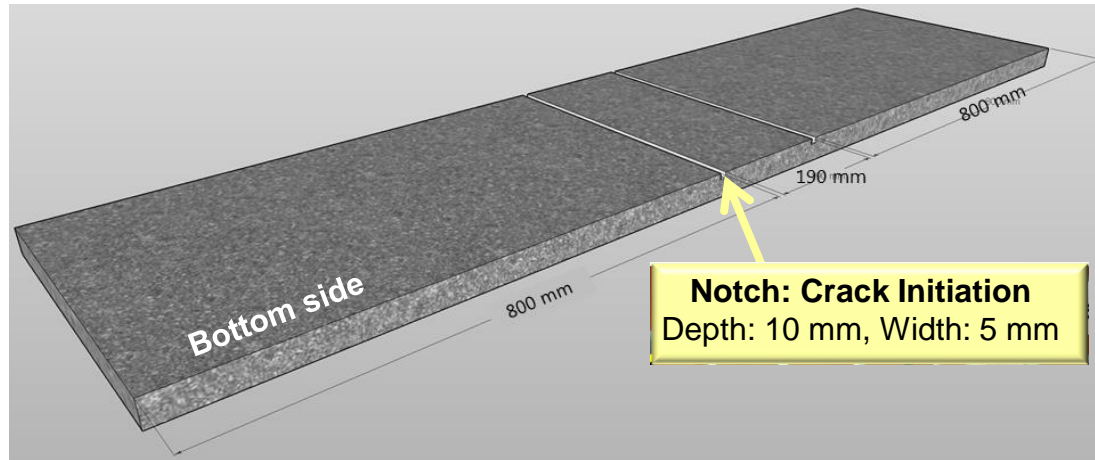
Bitumen 50/70 (5.9 %wt.)

Softening point: **65 °C**



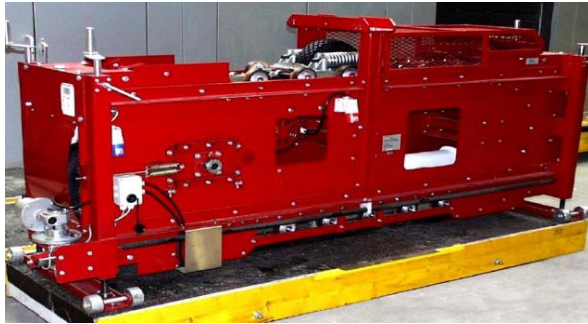
4 Slabs

(1800 mm x 435 mm x 40 mm)

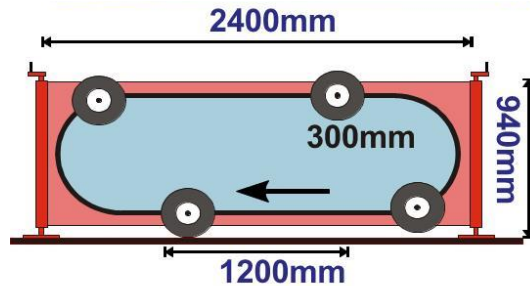
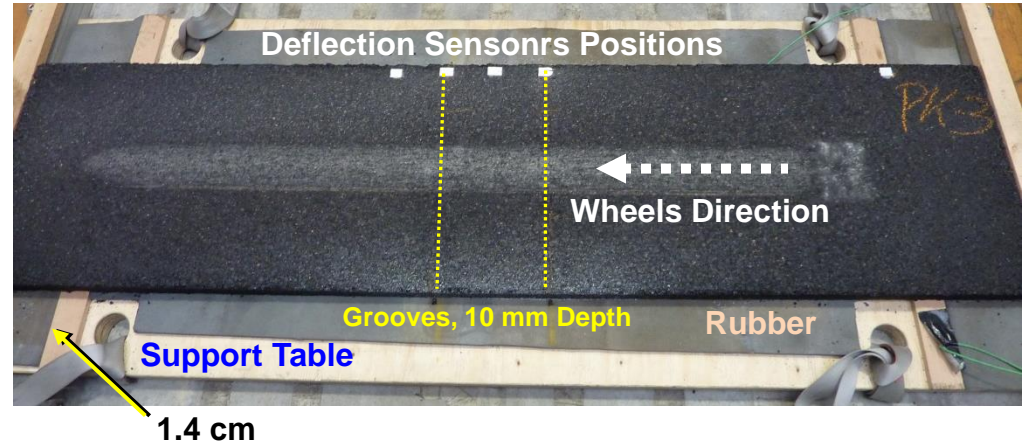


Experimental Setup

Mobile Load Simulator (MMLS3)



4 Slabs (1800 mm x 435 mm x 40 mm)



Test Temperature: 18°C
ca. 7000 cycles/hour
Tire Pressure: 600 kPa
Load: 2.1 kN

Experimental Procedure (3 Steps):

1. Damage phase
2. Healing process
3. Validation phase (until failure)



Experimental Setup

Healing Process



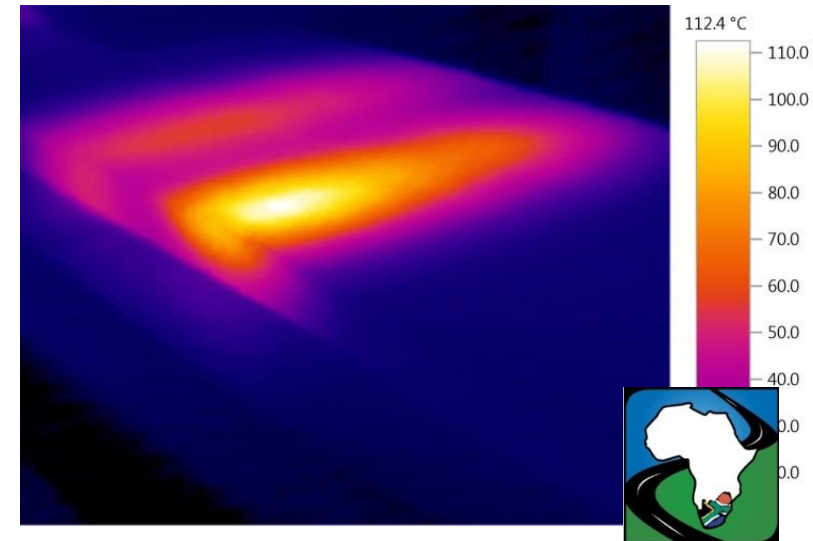
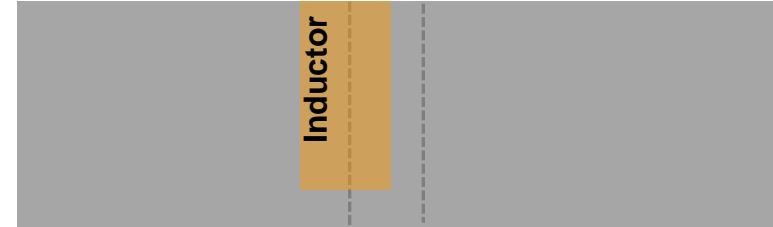
Heating Temperature: ca. 75°C

2 Healing areas (notches)

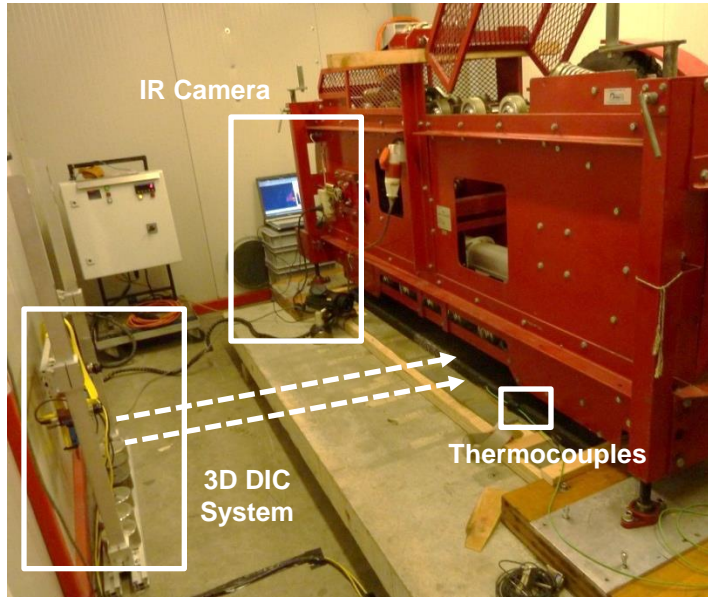
Process: 4 x steps (60-90 s)

Overheating controlled

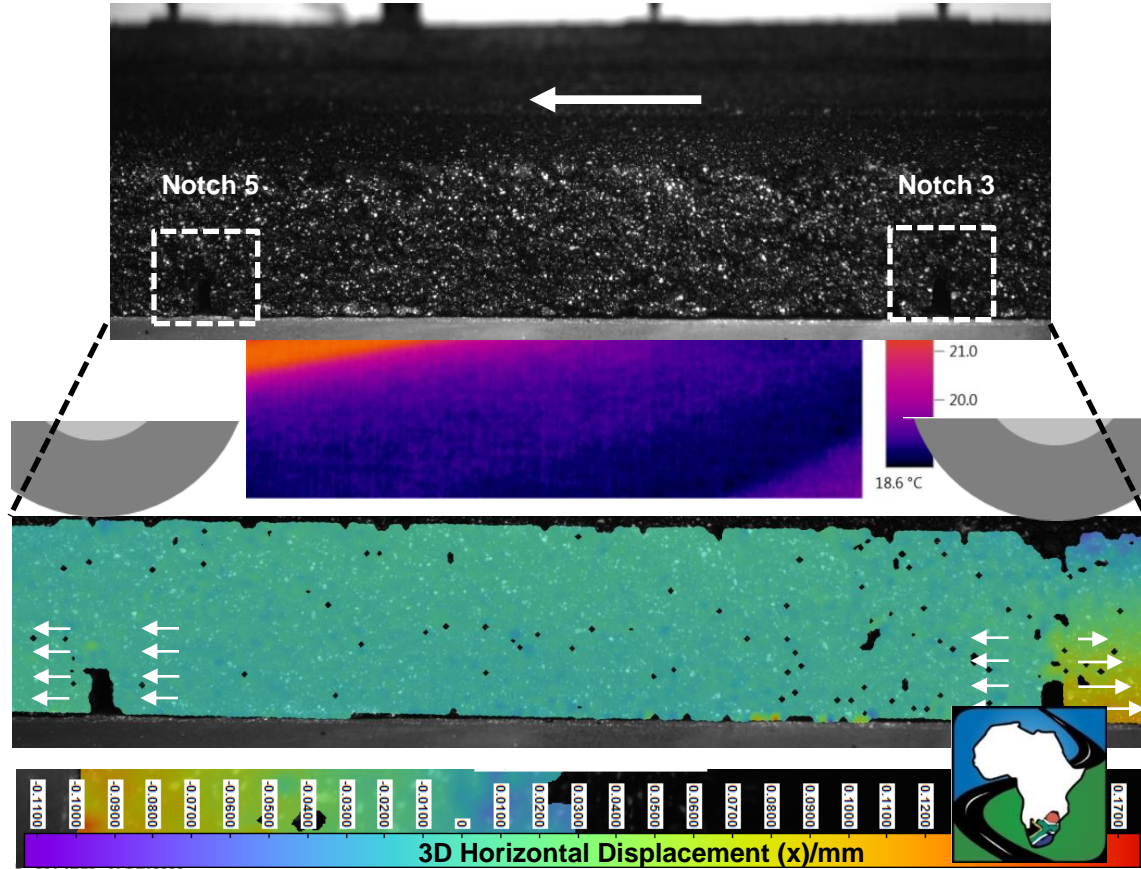
ca. 40 h Post-healing



Experimental Setup



Damaging Process

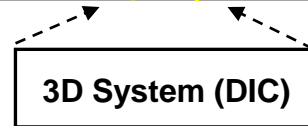
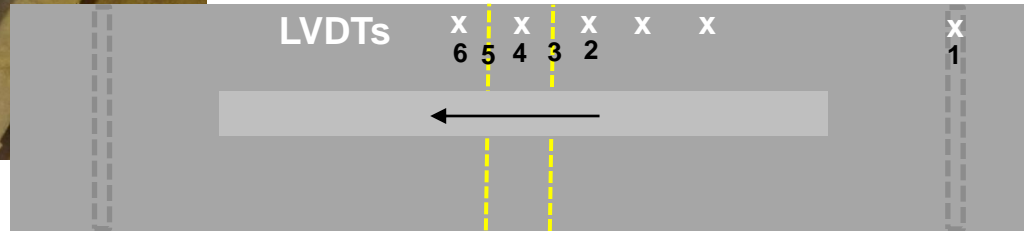
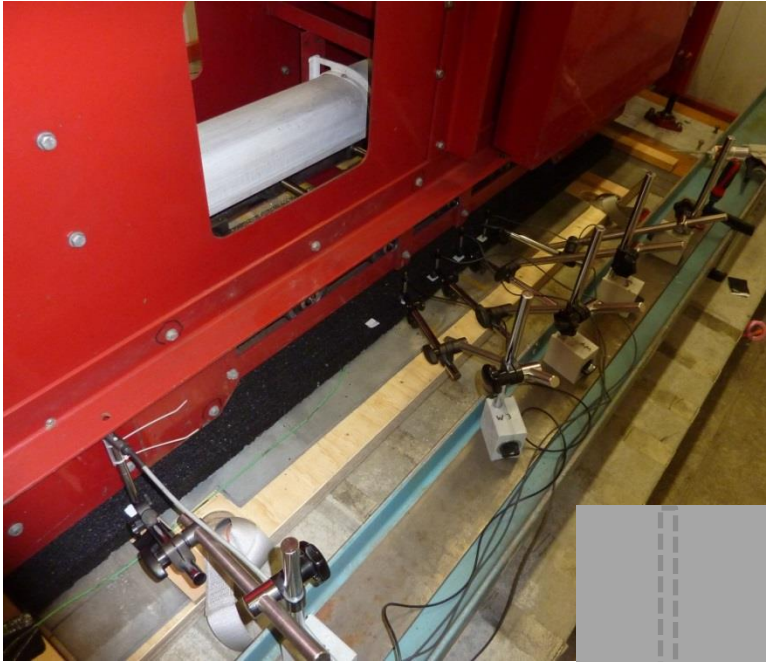


Experimental Setup

Damaging Process

Vertical Deformation Sensors

LVDT: Linear Variable Differential Transformer



Experimental Results

✓ **Slab A:**

Damage phase: **15000 cycles**



✓ **Slab B:**

Damage phase: based on “continuous” **3D image** analysis

✓ **Slab C:**

Damage phase: based on “continuous” **3D image** analysis



✓ **Slab D: Multiple Healing Analysis**

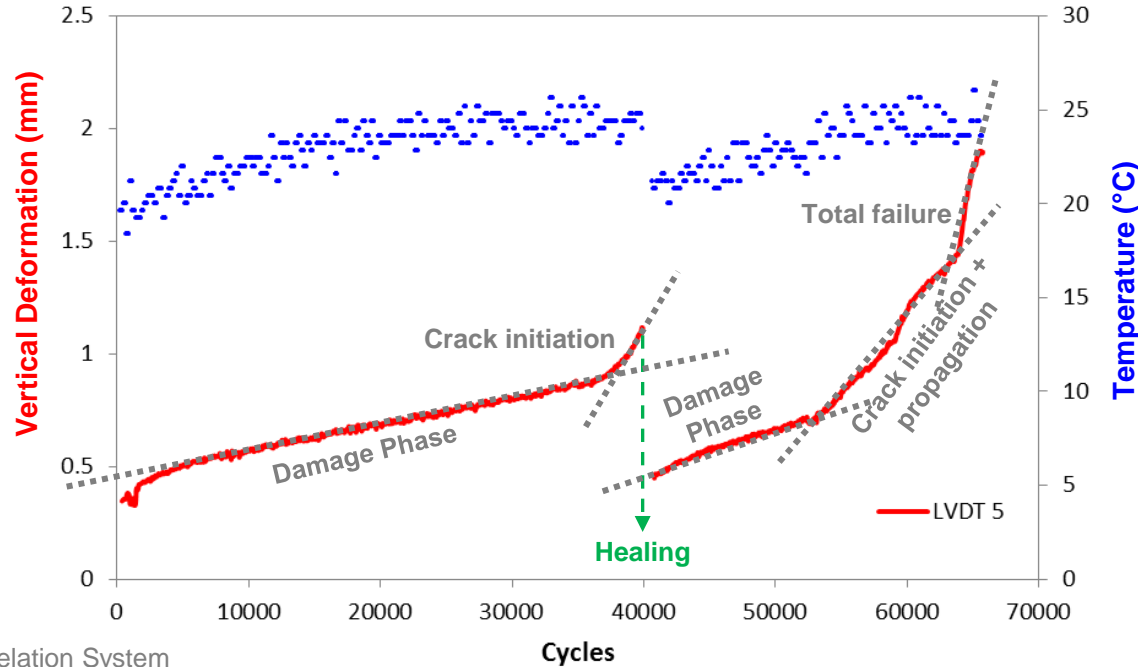
20000 cycles (no damage) + 15000 cycles (damage) + 15000 cycles (damage)

+ 12000 cycles until failure (notch 3)

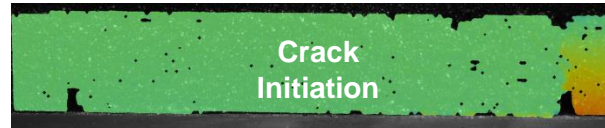


Experimental Results

Experimental Phases

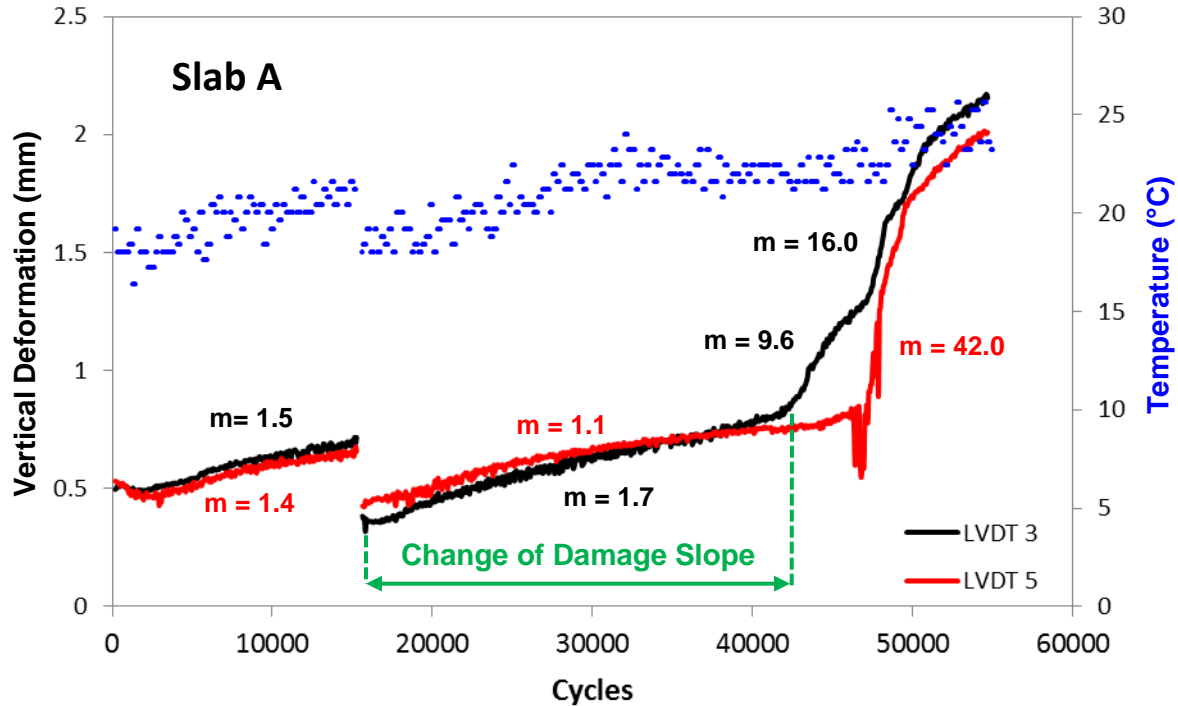


3D DIC: 3D Digital Image Correlation System



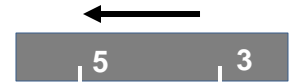
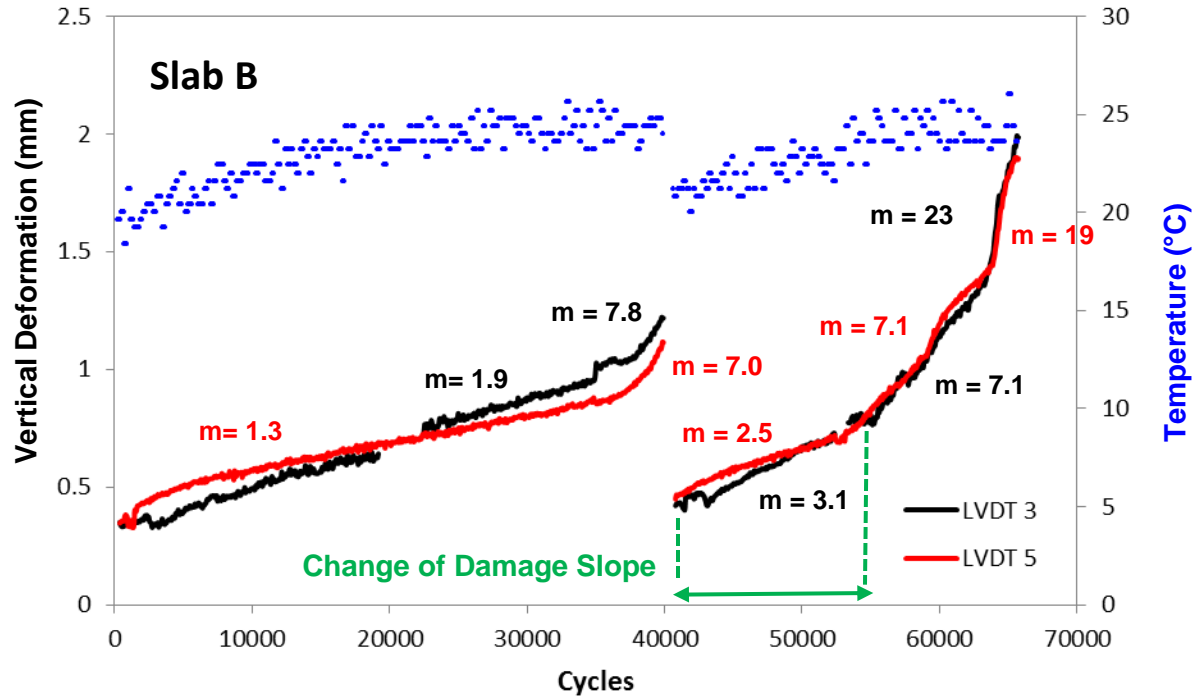
Experimental Results

Slab A: Damage phase: **15000 cycles**



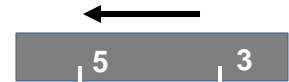
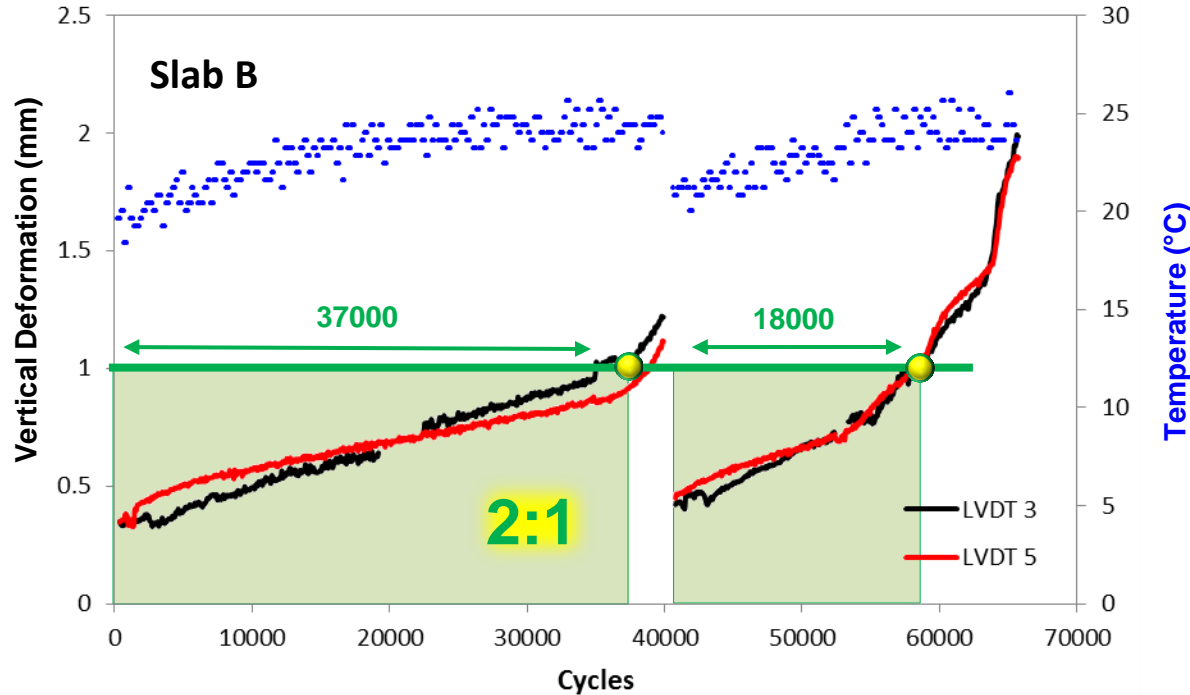
Experimental Results

Slab B: Damage phase: based on “continuous” 3D image analysis



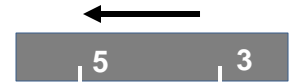
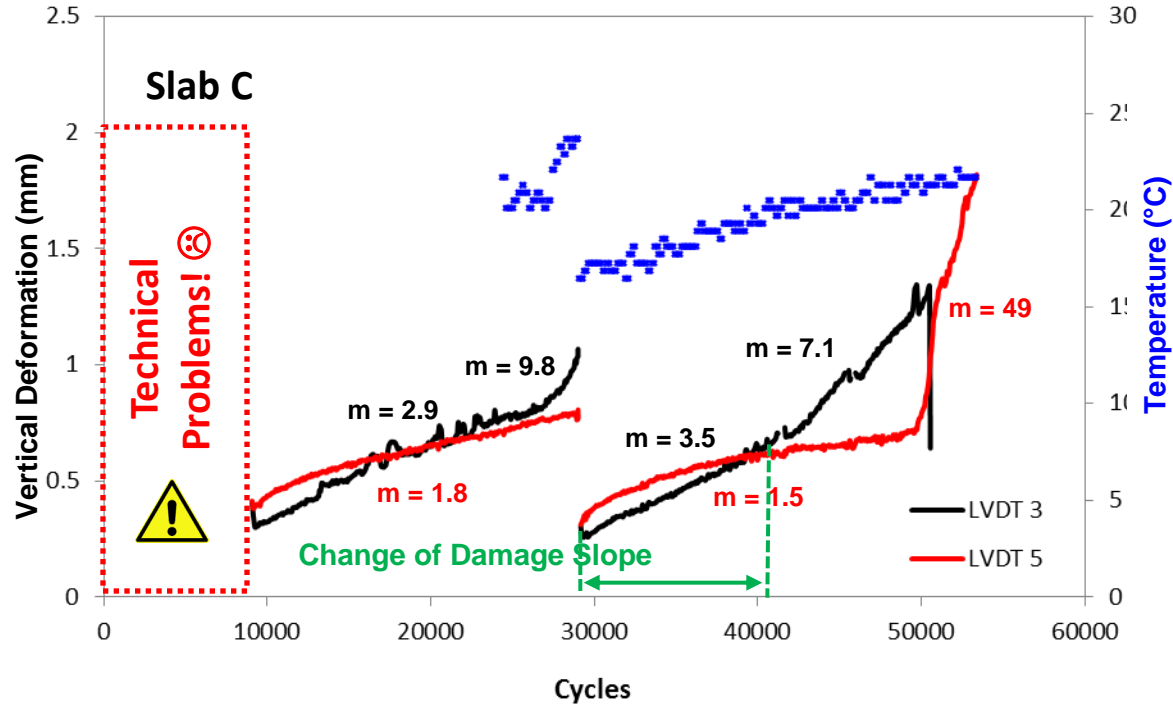
Experimental Results

Slab B: Damage phase: based on “continuous” 3D image analysis



Experimental Results

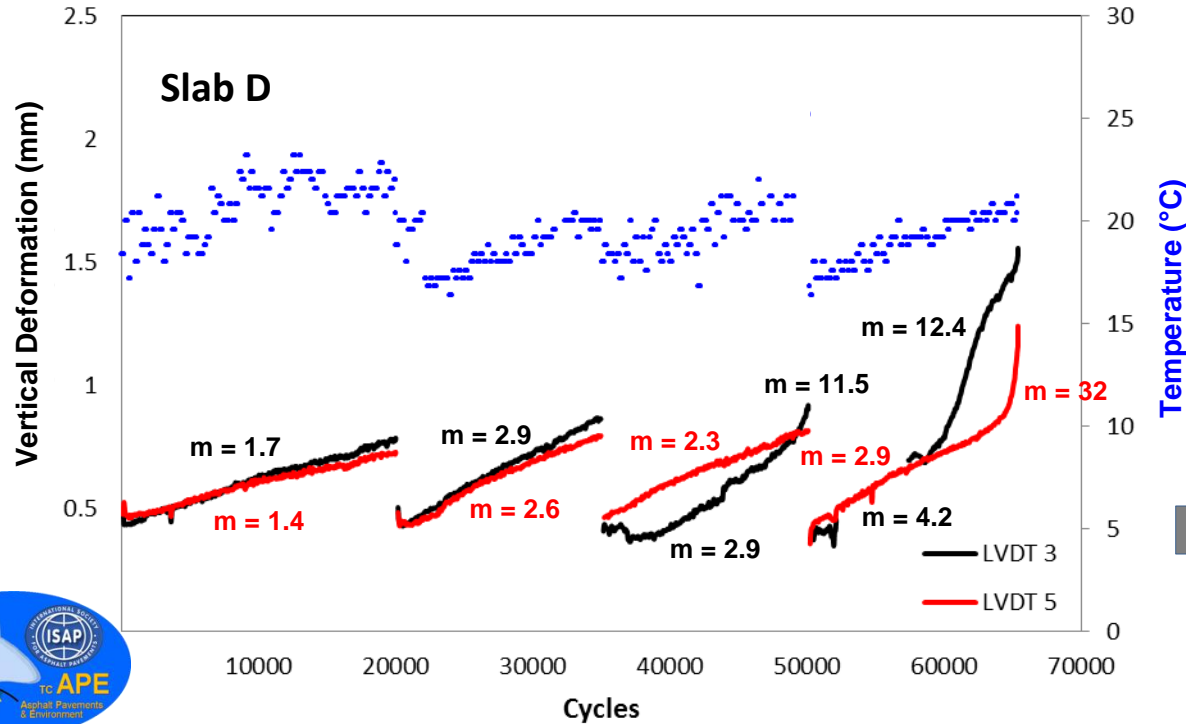
Slab C: Damage phase: based on “continuous” 3D image analysis



Experimental Results

Slab D: Multiple Heating Analysis

20000 cycles (no damage) + 15000 cycles (damage) + 15000 cycles (damage) + 12000 cycles until failure



62000 cycles instead of ca. 40000 cycles (as for Slab B) !!
= additional 50%



Conclusions

- ✓ Development and validation of a **new method** for evaluating the healing of asphalt slabs (**up-scaled**) by induction heating.
- ✓ The **enhancement of the life** of the pavement due to the healing process has been confirmed in a **larger scale**.
- ✓ After healing, the initial **performance** is **recovered** (LVDT) and the **damage** is **healed** (3D DIC).
- ✓ The **number of cycles** until total failure is **longer** when the healing process is carried out **before damage** starts (**here 50% longer**)
- ✓ The effect of **multiple healing** process as **maintenance technique** has been proven.





**Thank
You !**