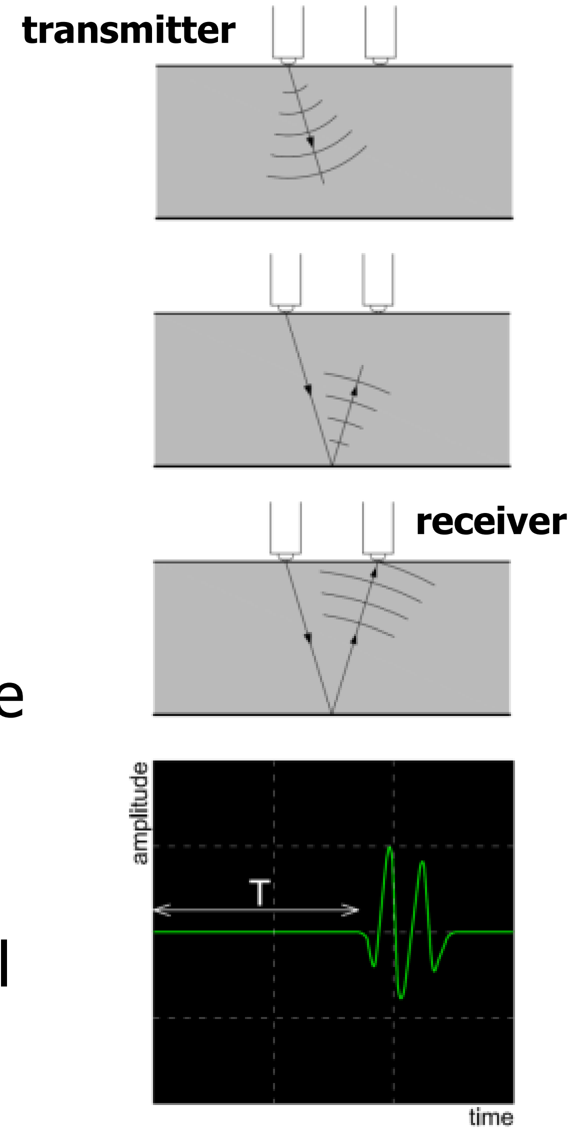
Ultrasonic Tomography, a non-destructive measuring technique for analysis of concrete roads.

Marijn Lybaert
Belgian Road Research Centre (BRRC)

Principle of ultrasonic tomography

- Ultrasonic sound waves are sent out by a transducer (transmitter)
- Waves are reflected at the boundary layer between different materials
- Reflected waves are collected at the surface (receiver).
- Time-of flight used to calculate distance till boundary layer



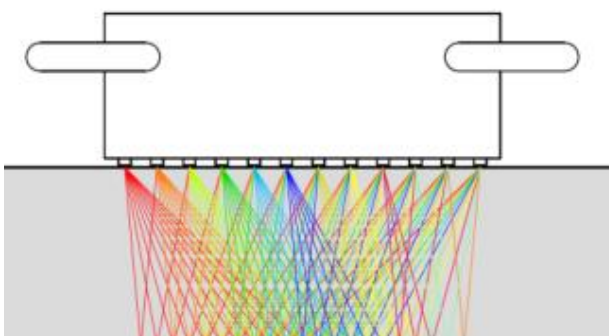
But...

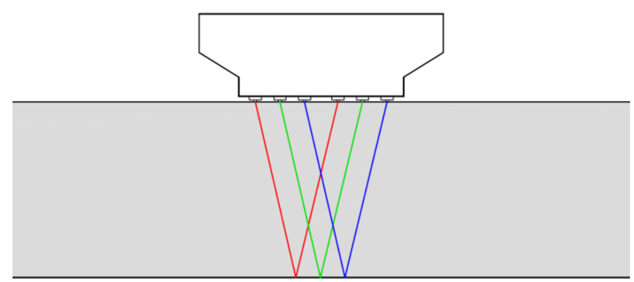
Concrete = heterogeneous material
(cement, aggregates, pores, cracks, …)

Conventional elastic wave based methods are not reliable!

⇓

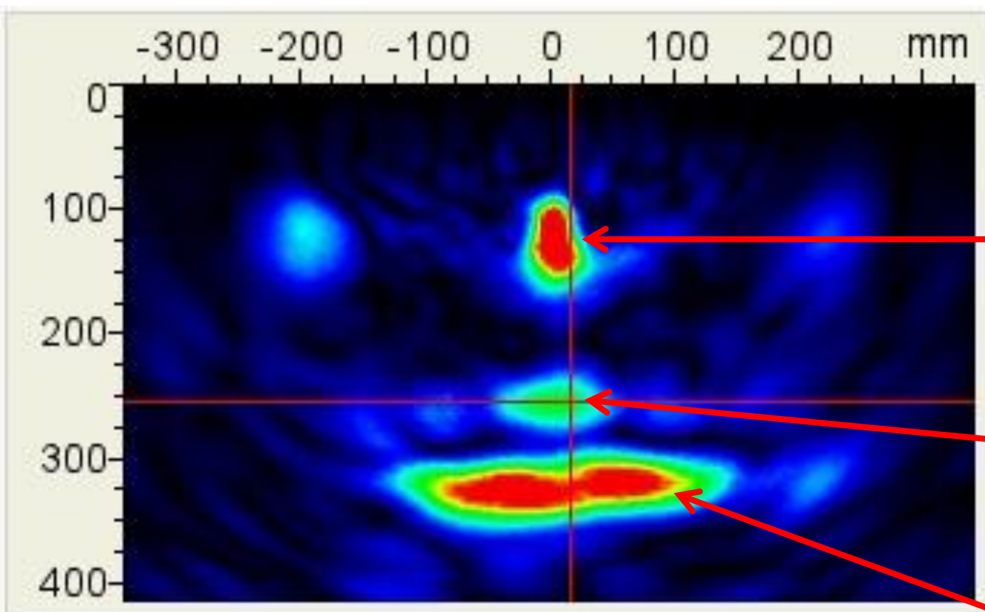
Development of the dry point contact (DPC) ultrasonic array technology





Example scan of a CRCP

- 2D reconstruction of the concrete
- High intensity of reflection areas indicating changes in acoustic impedance



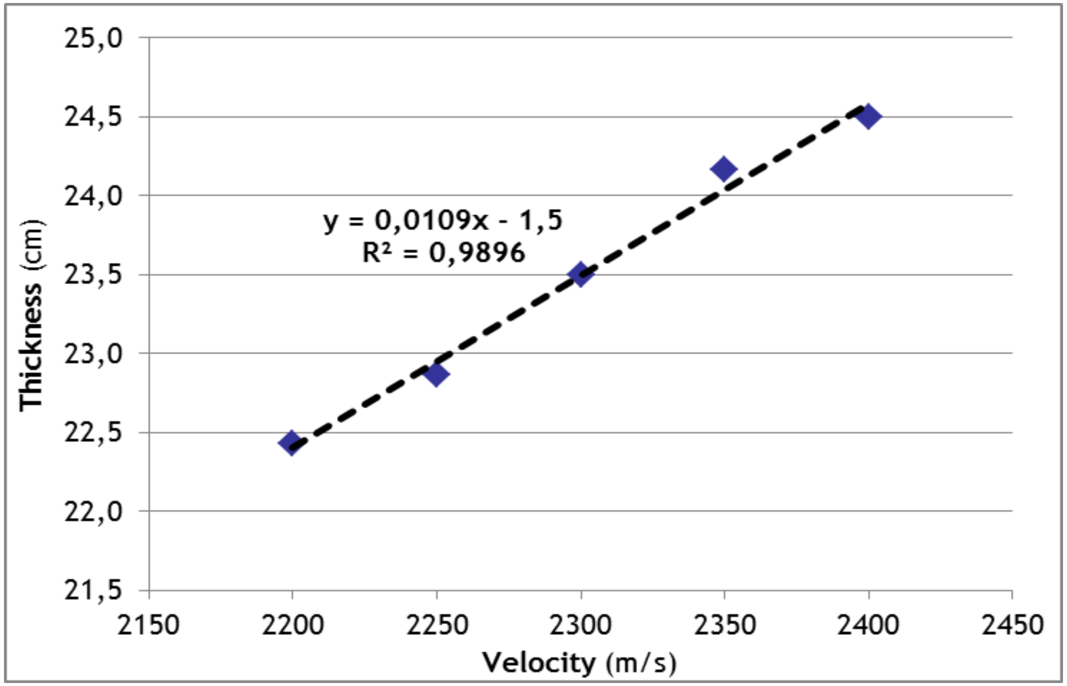
Longitudinal rebar

Interface concrete pavement / asphalt layer

Bottom of asphalt layer

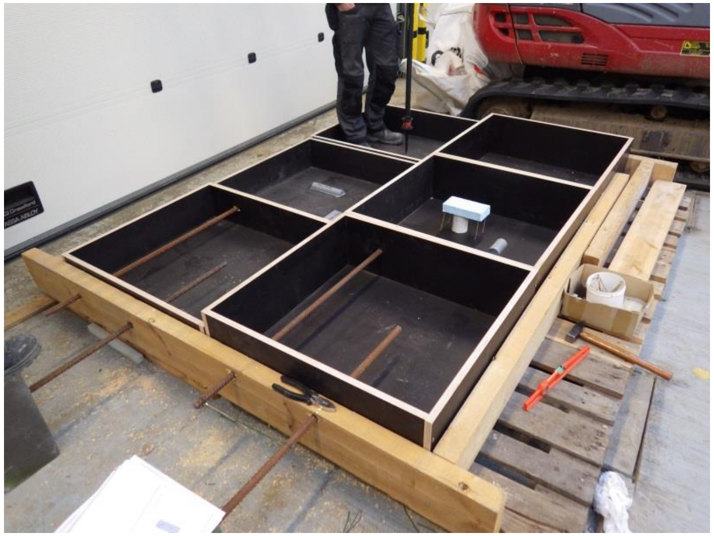
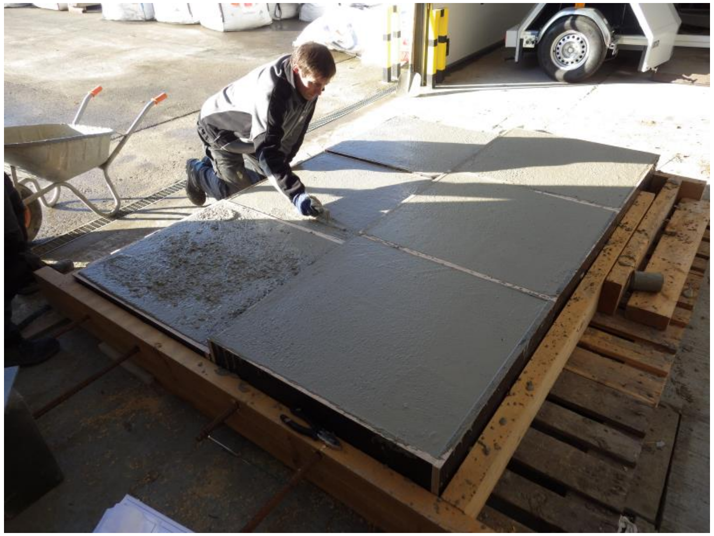
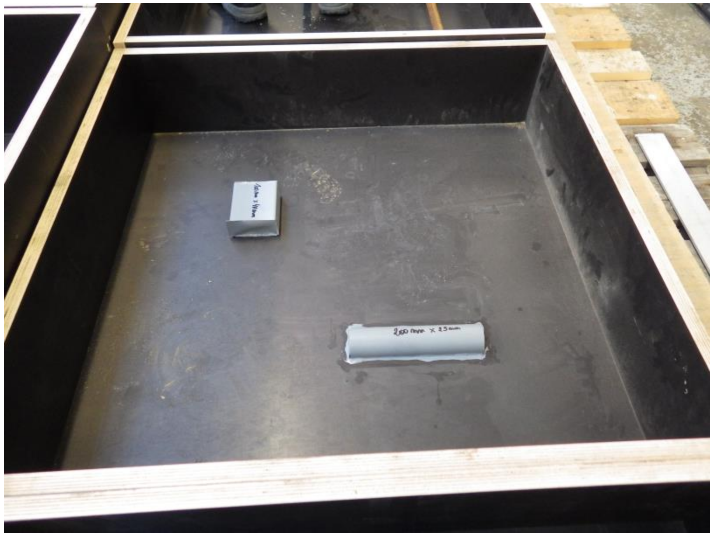
Relation between velocity and measured thickness

- Linear regression between used velocity (m/s) and measured thickness (cm)
- Small difference in velocity (2 %) leads to considerable difference in measured thickness (5 mm).

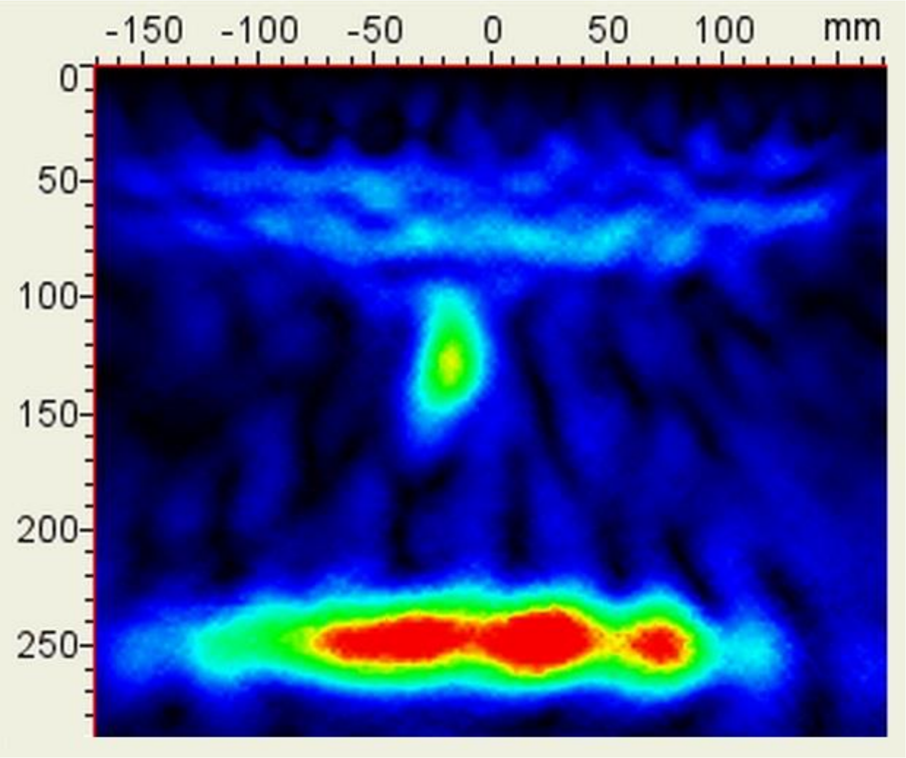


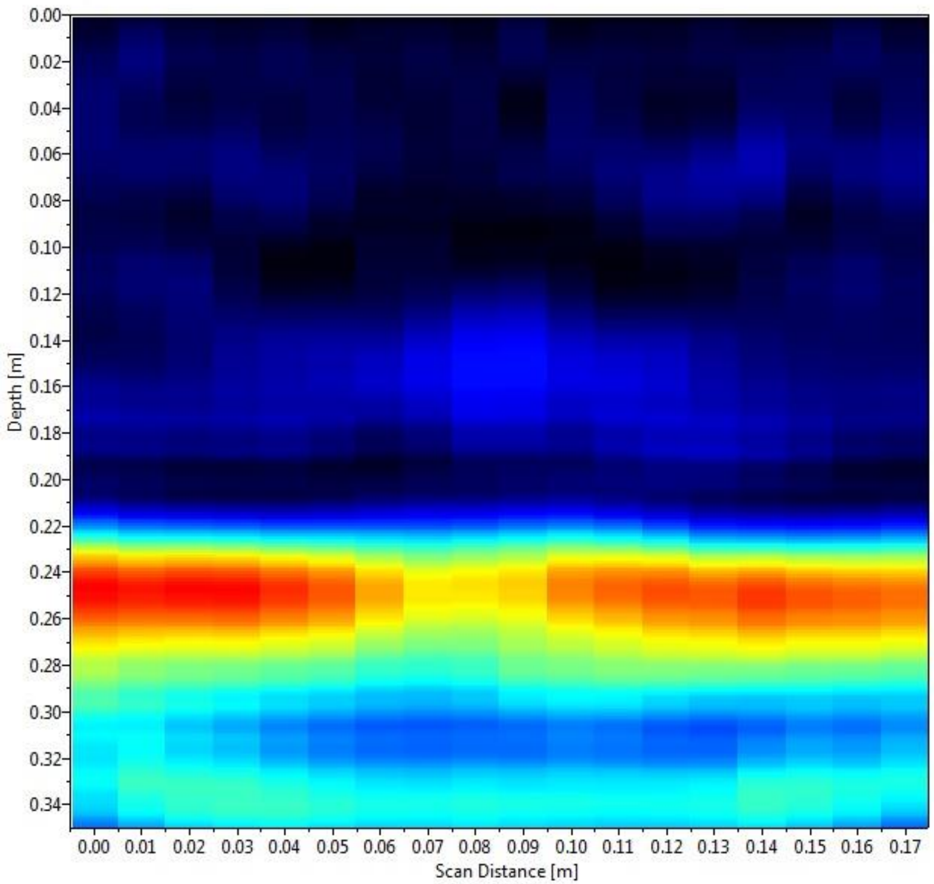
$$C_s = \sqrt{\frac{G}{\rho}} = \sqrt{\frac{E}{2(1+\nu)\rho}}$$

Concrete test slabs

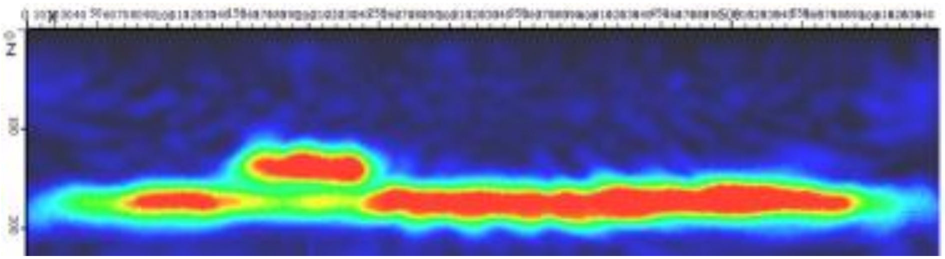




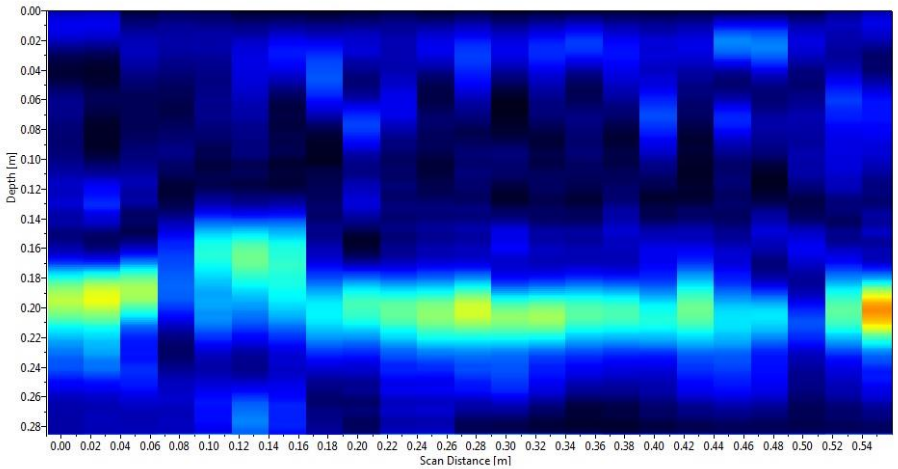

Concrete test slabs – MIRA vs Pundit-PL200PE

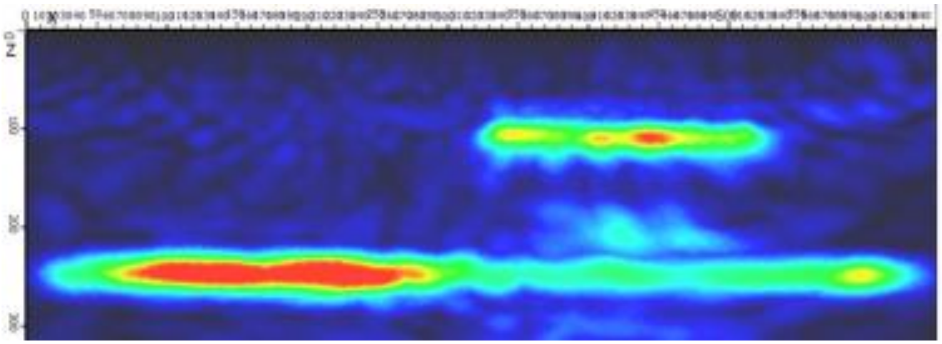


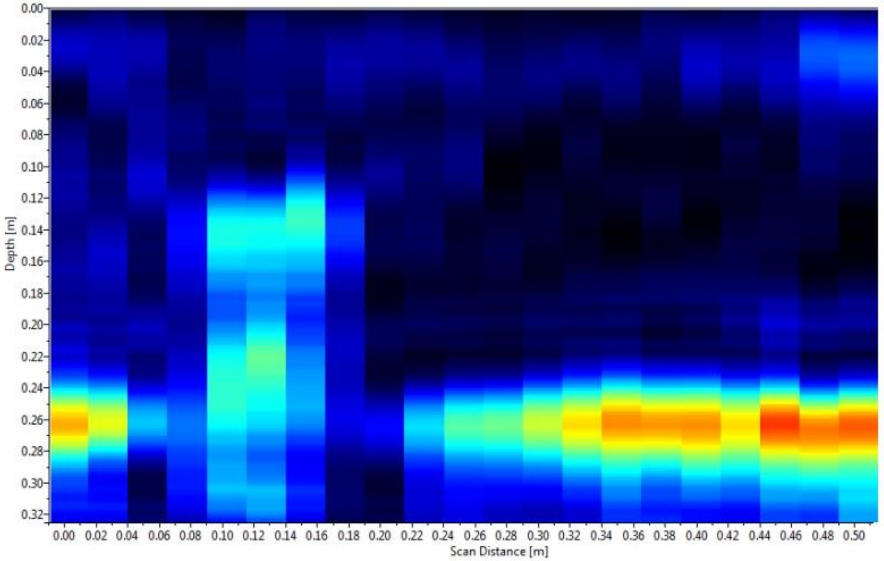


Concrete test slabs – MIRA vs Pundit-PL200PE



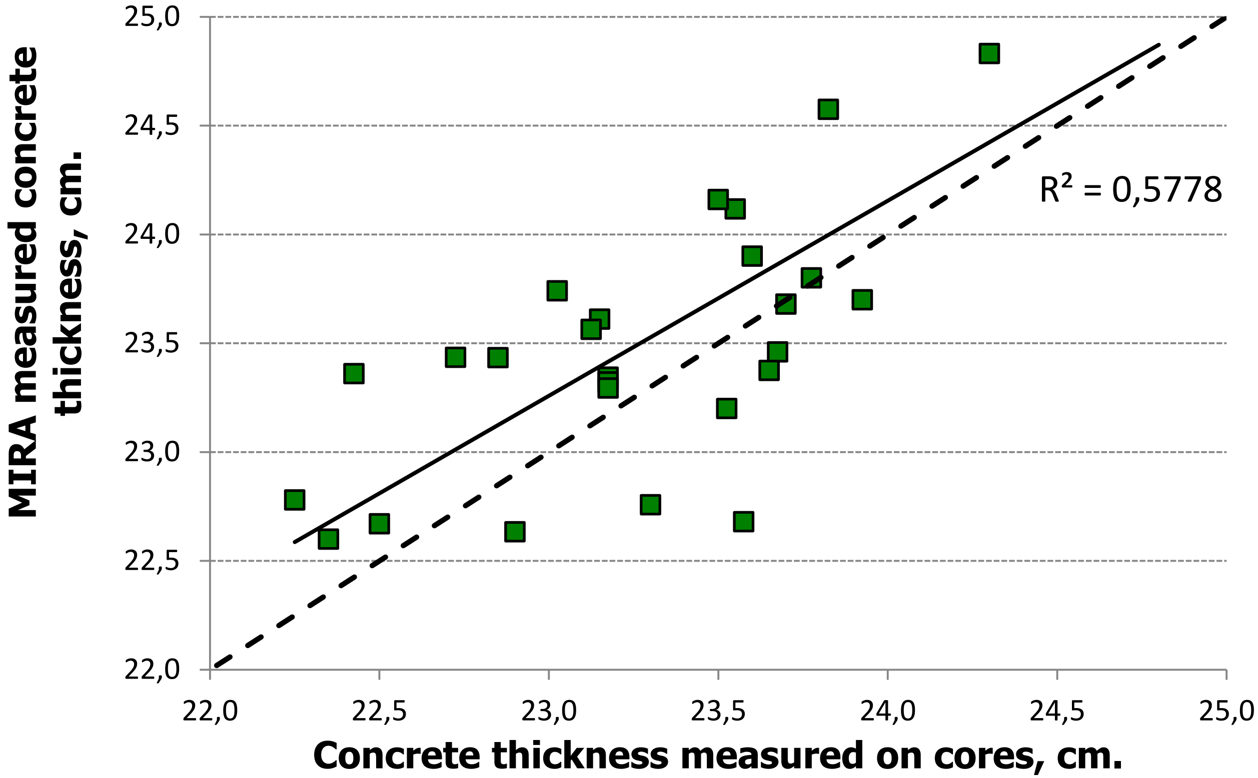






Thickness Measurements

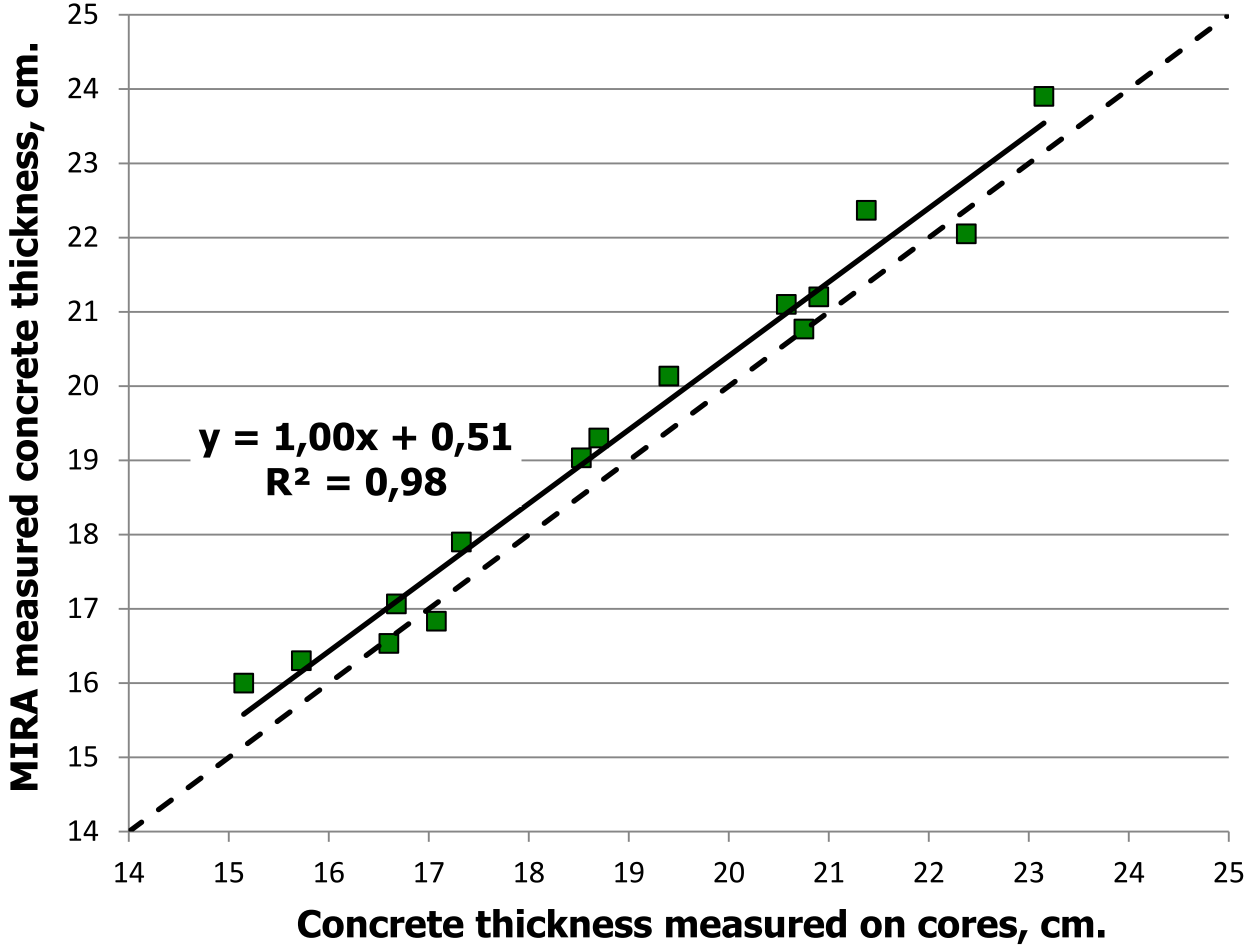
Thickness Measurements – E17 (CRCP)



- **Mean absolute difference:** 0,43 cm
- **Relative thickness deviation:** 0,1 to 4,2%
- **Average relative thickness deviation:** 1,9%

	Core thickness (cm)	MIRA thickness (cm)	Relative deviation (%)
Average (n = 27)	23,32	23,54 (+0,22)	1,9%
St. dev.	0,59	0,70	

Thickness Measurements – Elewijt (JPCP)



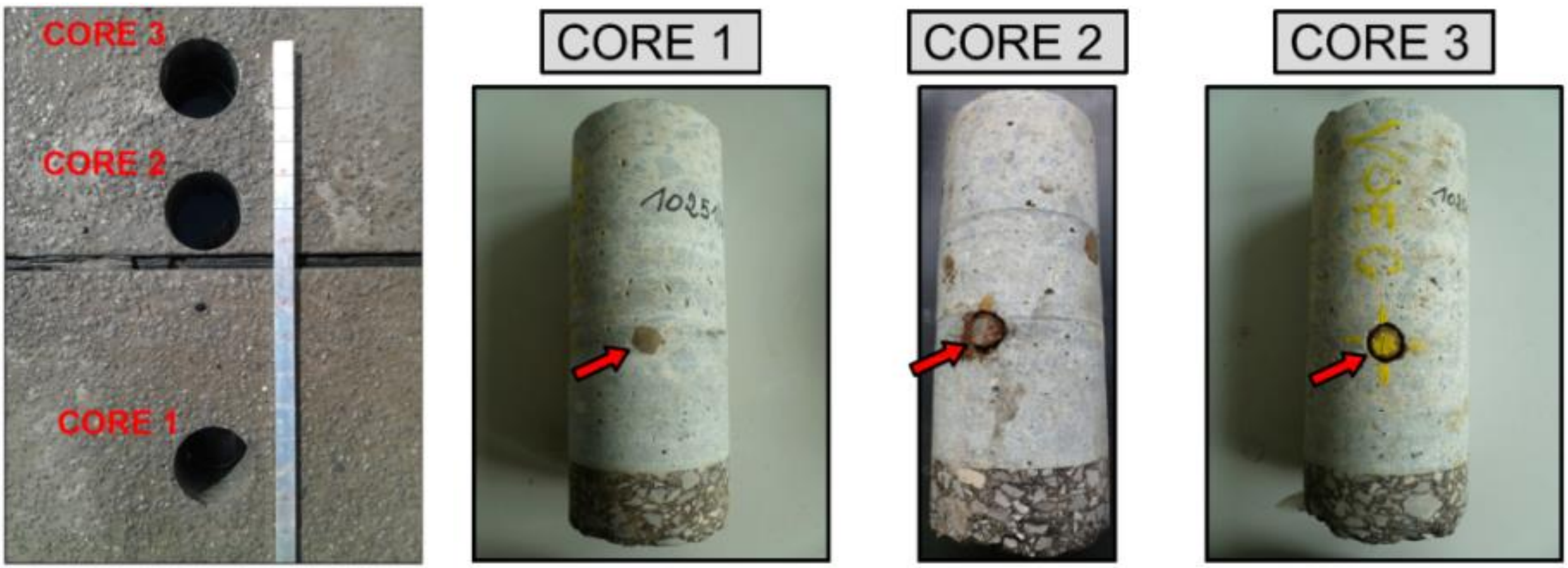
- **Mean absolute difference:** 0,49 cm
- **Relative thickness deviation:** 0,0 to 4,7%
- **Average relative thickness deviation:** 2,7%

CASE STUDY 1: Longitudinal joint widening on E34 motorway

- One lift CRCP
- 230 mm CRCP on 50 mm asphalt layer
- 2 phases, classic keyed construction joint with tie-bars
- Tie-bars inserted manually by drilling and gluing
- Tomograph used to determine position of tie-bars

- Joint width up to 40 mm
- Cracks near the joint

CASE STUDY 1:
Longitudinal joint widening on E34 motorway



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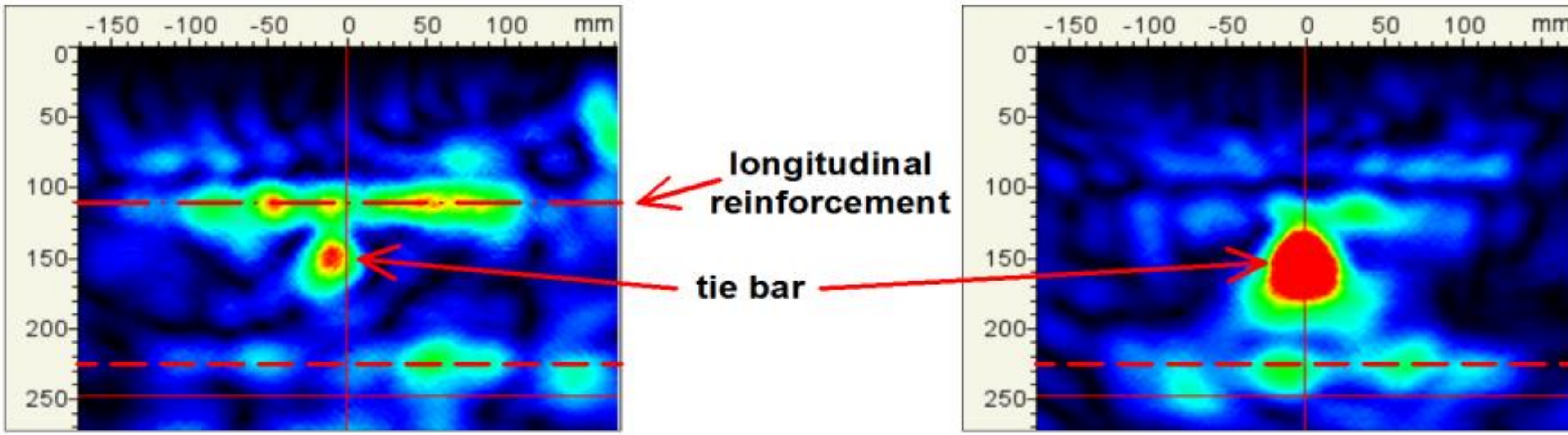
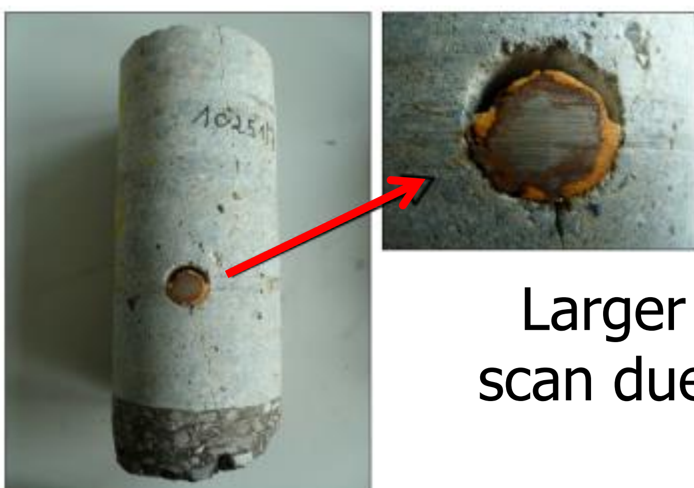
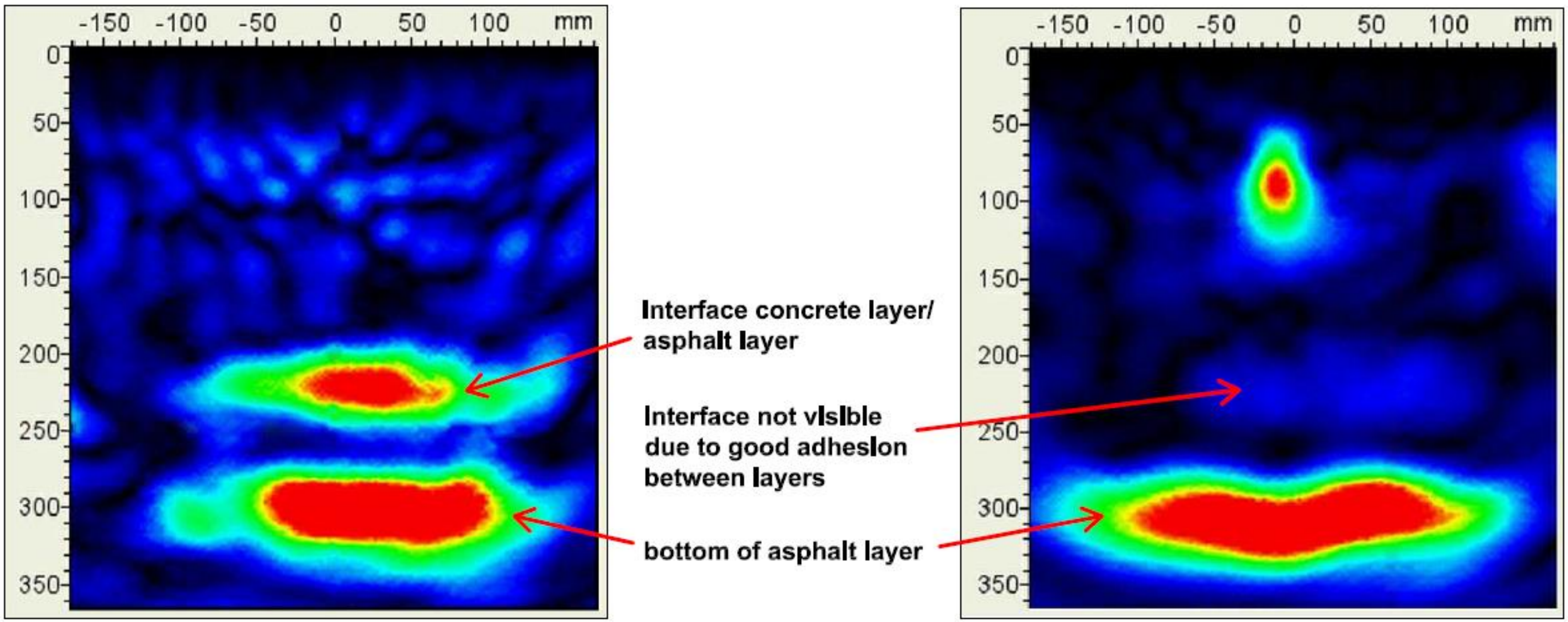




Larger reflection visible on tomographic scan due to large drilling hole and absence of glue

CASE STUDY 1:
Longitudinal joint widening on E34 motorway

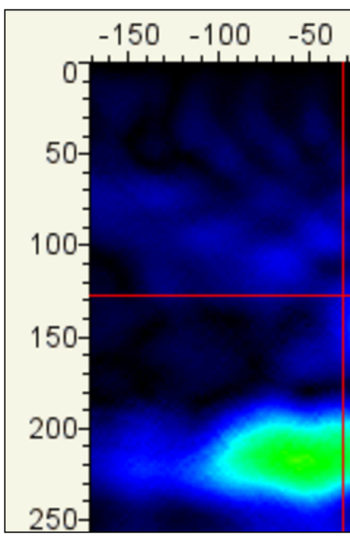


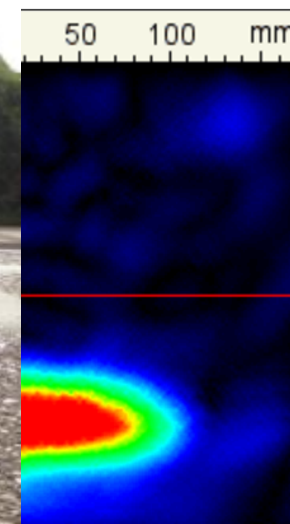
CASE STUDY 1:
Longitudinal joint widening on E34 motorway

Repair method for the longitudinal joint

CASE STUDY 2:
Faulting of concrete slabs at the N1 (Braken)

- Ultrasonic tomography measurements taken along transverse contraction joint to verify presence of dowels
- Dowels or ... of dowels could be l...

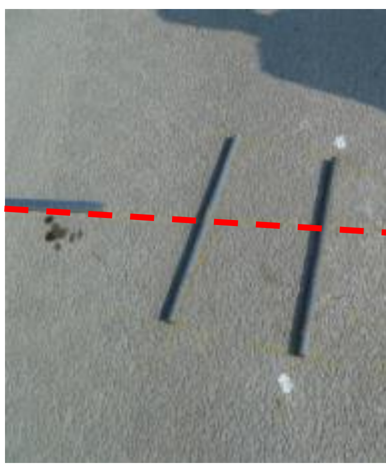




No dowels → high intensity reflection at bottom of pavement → cavity underneath pavement caused by erosion of base layer

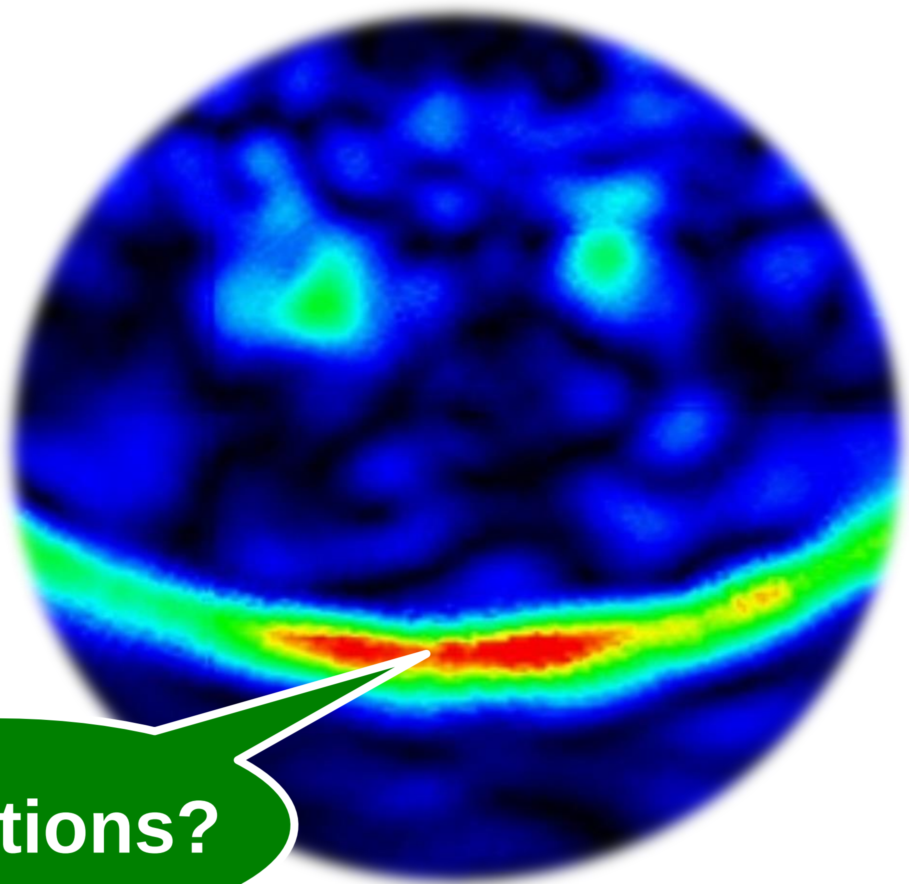
CASE STUDY 3:
Dowel misalignment on the R4 (Wachtebeke, Ghent)

- Ultrasonic tomography measurements taken along transverse contraction joint to verify presence of dowels
- Dowel misalignment along various joints
- Pavement demolished and reconstructed



Conclusions

- Ultrasonic tomography has proven to be a very promising non-destructive measuring technique for evaluation of concrete roads.
- Method can be used for thickness measurements and for in-situ analyses of different types of distresses.
- Future research necessary in order to incorporate the method in pavement management systems and quality control.



Thank you for your attention!

Questions?