INSPECTION OF PRESTRESSED CONCRETE ROAD BRIDGES BY ULTRASOUND 3D TOMOGRAPHER SYSTEM

Eng. Guy Rapaport

RAMBOLL

Infrastructure & Transport, Finland

BACKGROUND AND TERMS:

This presentation will refer to **POST-TENSIONED CONCRET BRIDGES**.
Typically girder bridges or slab bridges of 20-60 m long spans, overall lengths of up to several hundred meters.

Post-Tensioning in a Nutshell:

- **Post-tensioning systems:**

  - The prestressing steel is placed in duct embedded in the concrete structure.

  - The steel will be tensioned **after** the concrete structure has cured and reached a designed level of compressive strength.

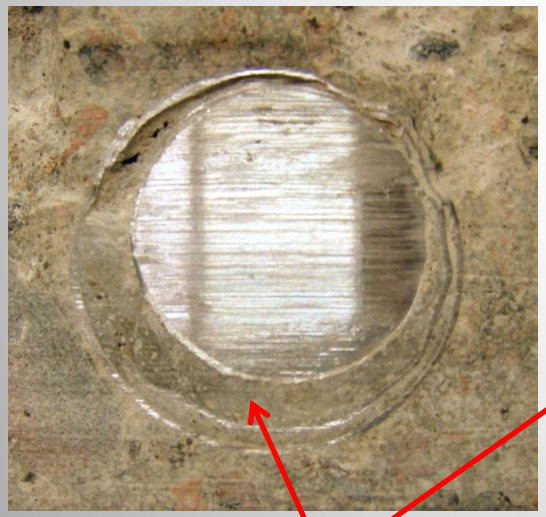
  - Afterwards, the ducts will be injected by cement based grout.

- Main roles of the injected grout:

  1) Permanent protection to the prestressing steel against corrosion, i.e. preventing ingress of water, chlorides and air into the duct.

  2) Structural function – intermediating forces to the surrounding structural concrete.

PRESTRESSING BAR



PRESTRESSING TENDON

INJECTION GROUT

Global Status Quo Regarding Post-Tensioned Bridges

- Dozens of thousands of aging post-tensioned bridges globally.
- Prestressing technique started been widely used in the 1960-70's – time to renovate!
- Post-tensioning technique not always implemented successfully.

  Severe durability problems have been discovered. There have been even some collapses.

Contractors demolishing the remaining sections of the failed bridge.

High levels of calcium chloride found in collapsed bridge grout

http://www.opacengineers.com/projects/Koror
http://www.docstoc.com/docs/38001174/Effective-Inspection-and-Monitor

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Risks and Problems of Post-Tensioned Bridges:

- The prestressing system is an **internal system** within the bridge structure => well hidden/locked inside the ducts.

  Corrosion of the prestressing steel is **not visible** and will **not be detected** by the regular investigation techniques.

- Prestressing steel corrosion is **dangerous**:

  The steel is concentrated in small amount of tendons which should provide substantial part of the bridge load carrying capacity.

  Failure of prestressing steel => trigger bridge collapse.

=>

Maintaining and monitoring the condition of those bridges should be a priority for safety and economic reasons.

This presentation describes a solution for evaluation of ducts injection by the **Ultrasound 3D Tomographer NDT system.**

Finally we can look into the internal prestressing system.

THE ULTRASOUND 3D TOMOGRAPHER SYSTEM (MIRA DEVICE)

Description of the System:

A state-of-the-art instrument for creating a 3-D representation of internal interfaces (defects, steel…) that may be present in a concrete structure.

The **detection**: scanning and interpretation is done almost IN REAL TIME (3 sec. delay) AND IN SITU.

Scanning: only from one side of the object surface.

Implementation of the Tomographer system in regarding to post tensioned bridges:

- Detection of **voids** in grouted tendon ducts
  IF THERE ARE VOIDS => SEVERE DURABILITY PROBLEMS ARE LIKELY TO BE FOUND !
- Locating of ducts and reinforcement
- Detection of casting defects (e.g. anchoring zones)

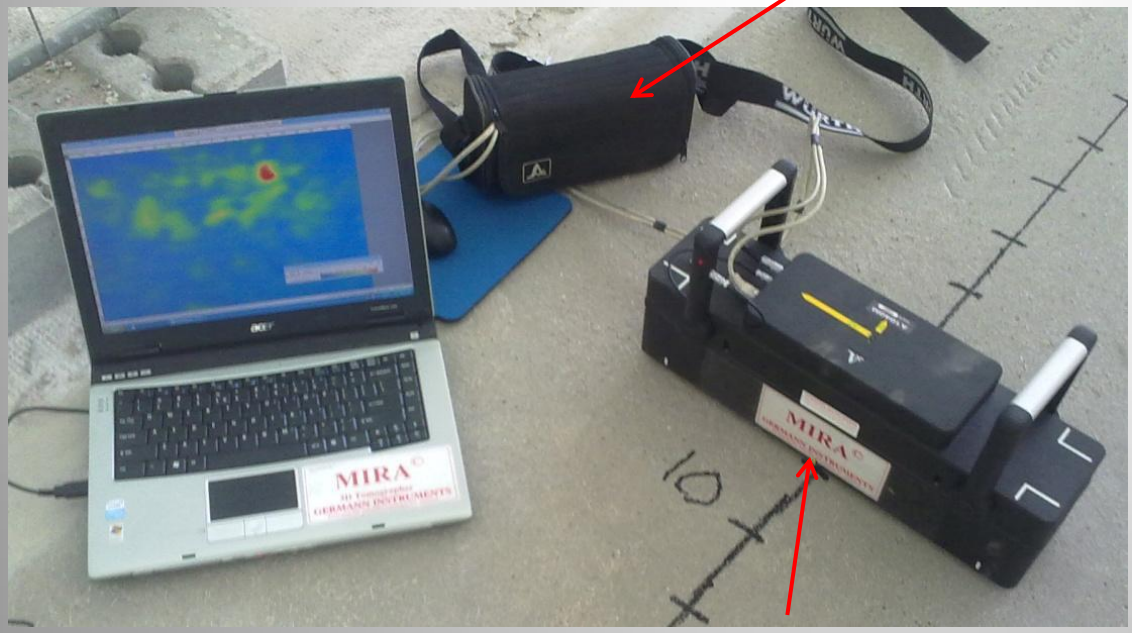
Effective scanning depth :

Usually Up to 1 m in heavily reinforced structures (bridge decks, girders)

Up to 1,5…2 m in lightly reinforced structures

The 3D Tomographer System Components:

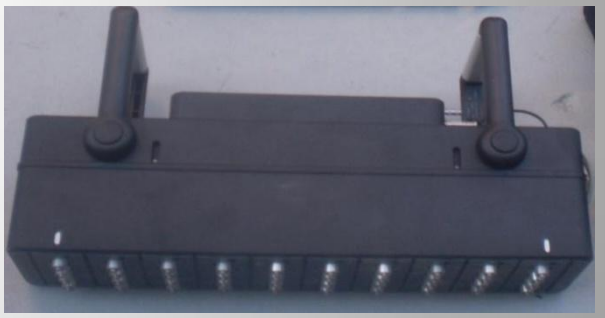
1) Antenna composed of 40 dry point transducers arranged in an array and a control unit.
2) Laptop with the MIRA software (a SAFT algorithm based software).
3) Antenna power unit with wireless net transmitter.



DPC transducers

THE OPERATION PROCESS:

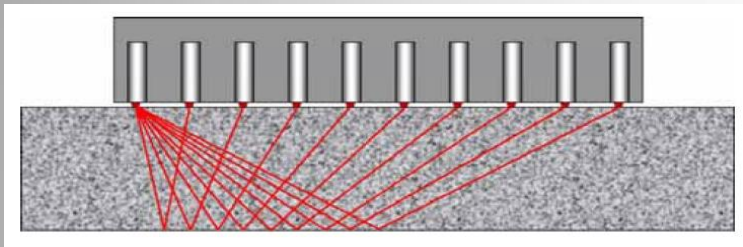
CONTROL UNIT: Operates the transducers.
Raw data is transmitted in real time to the computer.
COMPUTER: data collection, data analysis and graphical 3D presentation of the reflected interfaces within the concrete object (< 3 seconds).

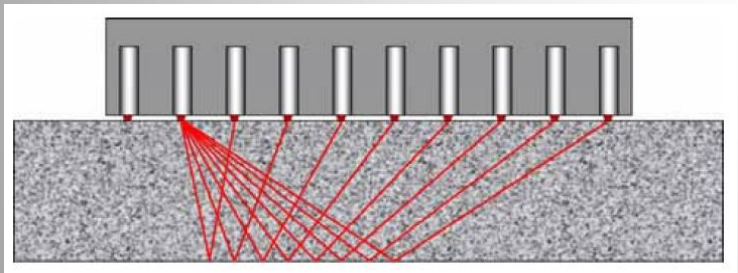


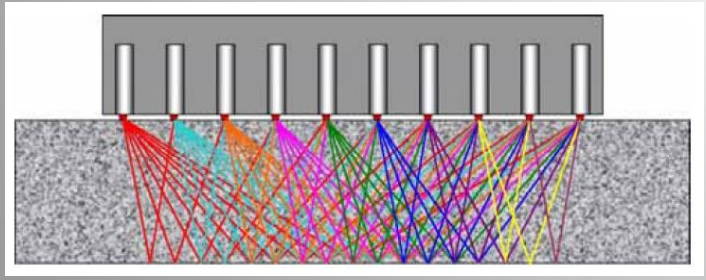
DPC transducers

Principles of the 3-D Tomographer System Technique:

Based on the **ultrasonic echo method** using transmitting and receiving transducers in a "Pitch-Catch" configuration,
i.e. one transducer sends out a stress-wave pulse and another receives the reflected pulse.







The Antenna operation process:

First row transmits,
the 9 remaining rows receive

Second row transmits,
the 8 remaining rows receive

Antenna operation,
all phases

…Principles of the 3-D Tomographer System Technique:

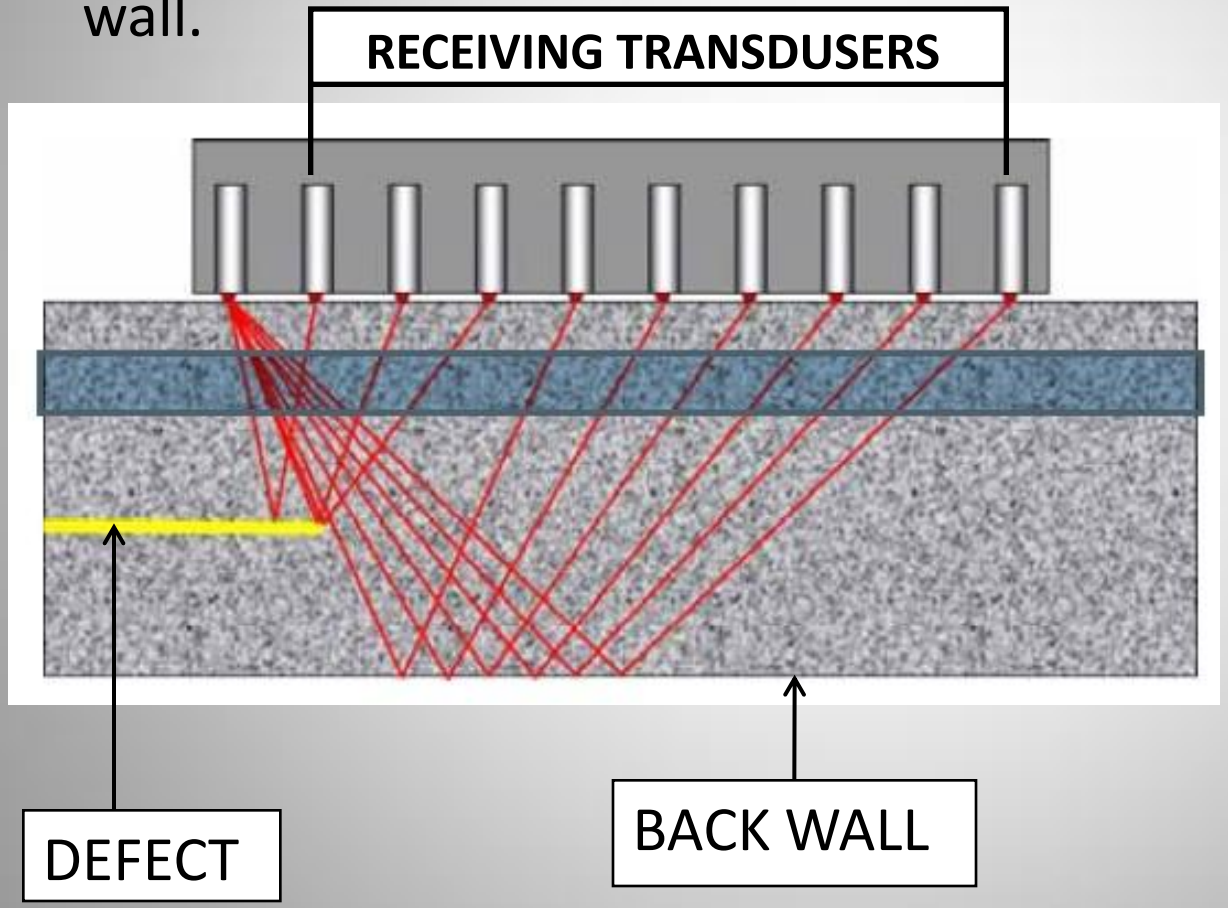
- The transducers introduce into the concrete **low frequency** (20-100 kHz) **pulses of shear waves**

↓

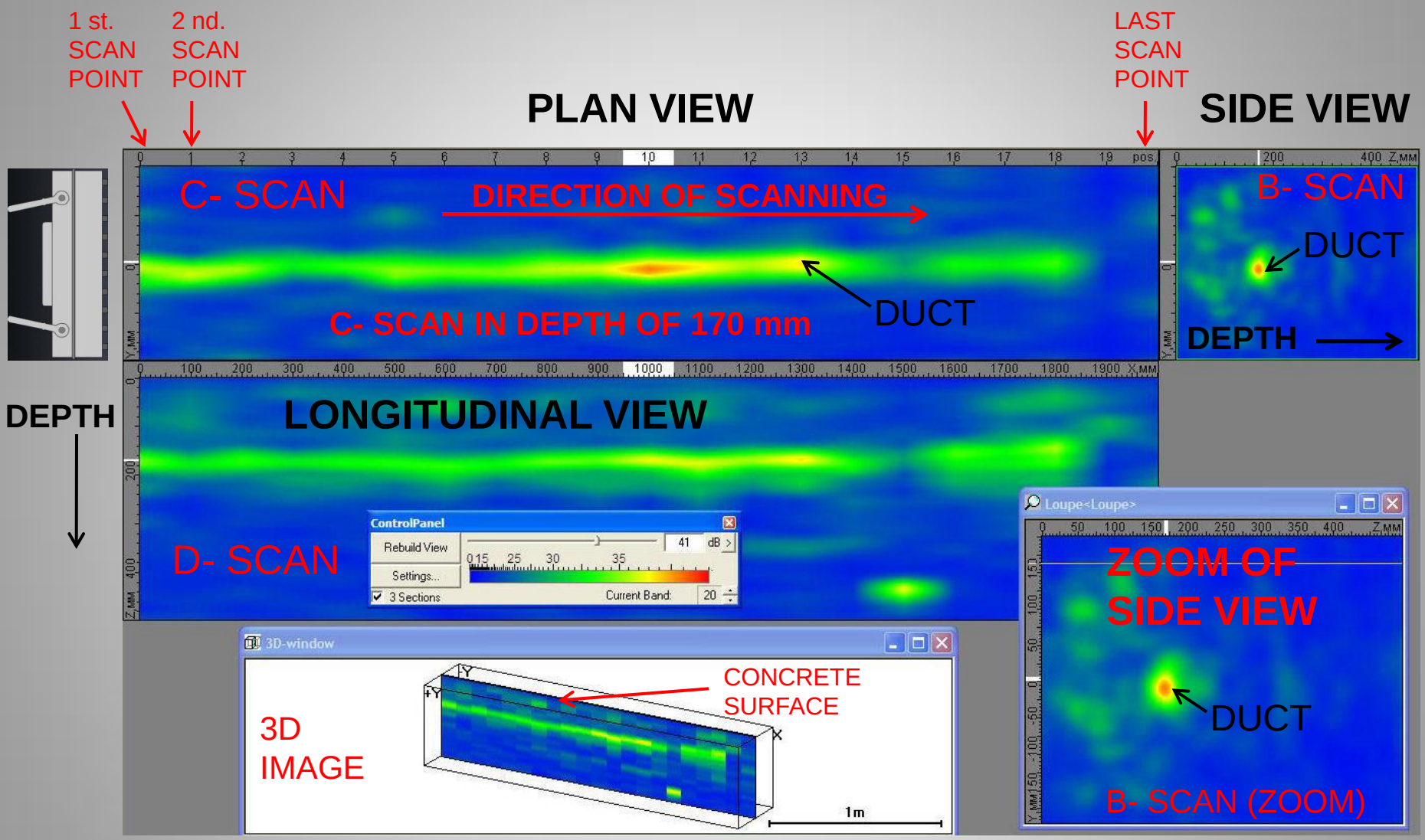
Suitable for testing heterogeneous materials (concrete).

Detection of a defect:

Defect forming a sufficiently large concrete-air interface =>
a portion of the pulse will be reflected by the defect and will arrive at the receivers sooner than reflections from the back wall.



THE VISUALIZATION SOFTWARE:



Colour scale: more red => the more intensive wave reflections => different material interfaces (such as steel, air…)

TEST CASES – ACTUAL USAGE OF THE 3D TOMOGRAPHER SYSTEM:

CONDITION EVALUATION OF PRESTRESSED BRIDGES NEAR THE ANCHORAGE ZONE

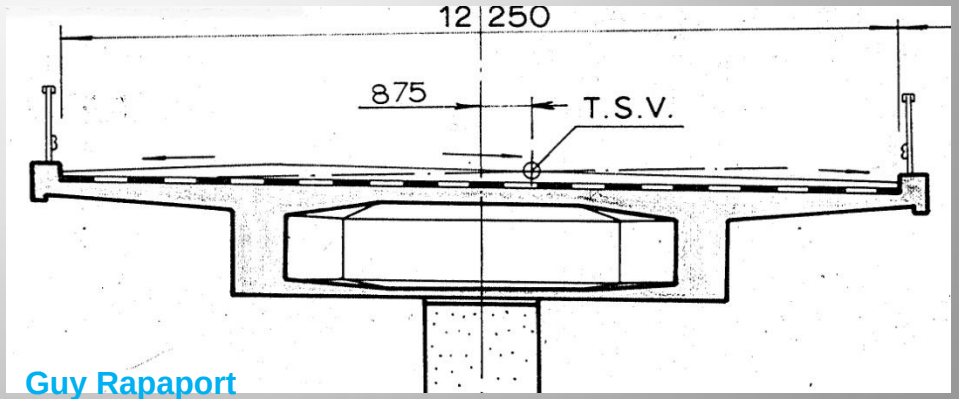
INVESTIGATION CASE No. 1 - LIEVIÖ OVERBRIDGE, FINLAND

General Description of the Bridge:

- Location: motorway no. 1 between Helsinki and Turku.
- Year of construction: 1971.
- The main type of the bridge: continuous prestressed concrete box-girder bridge.

Main dimensions:

Spans: 23,88 + 33,78 + 24,00 m
Overall length: 102,00 m
Length of deck: 82,45 m
Horizontal clearance: 13,05 m



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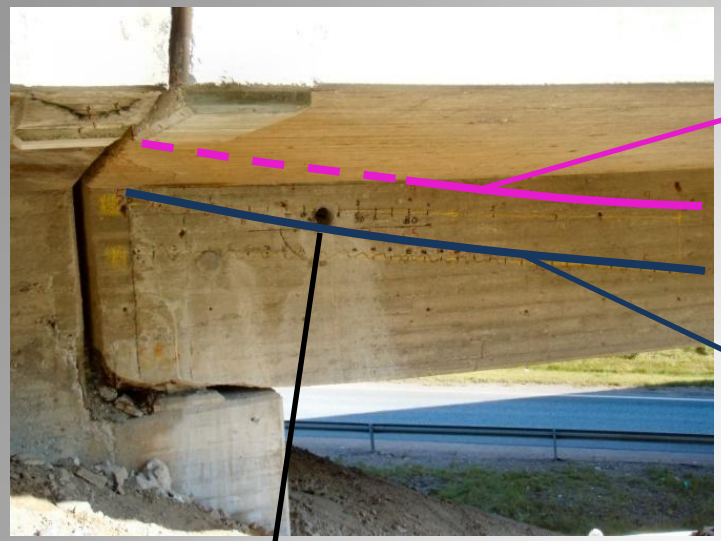
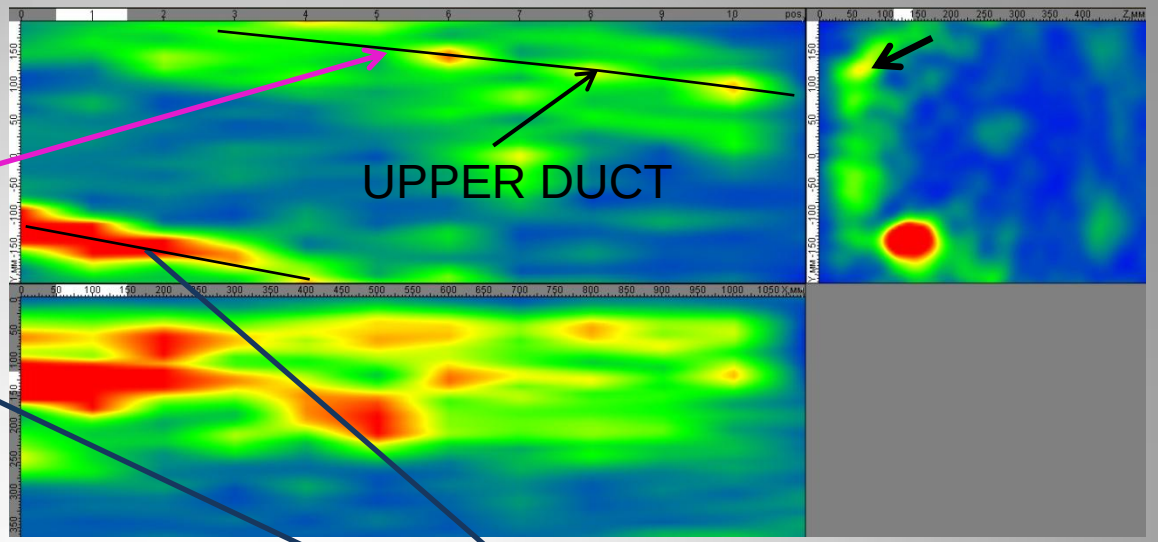
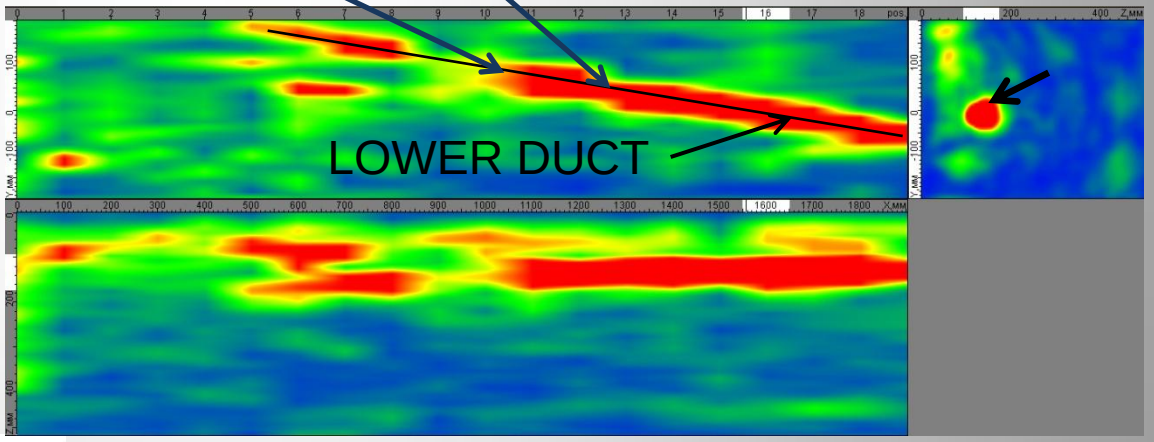
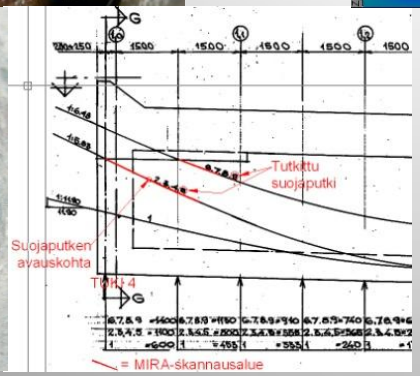
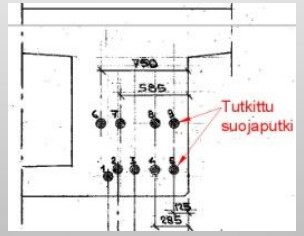
LOCATION 1











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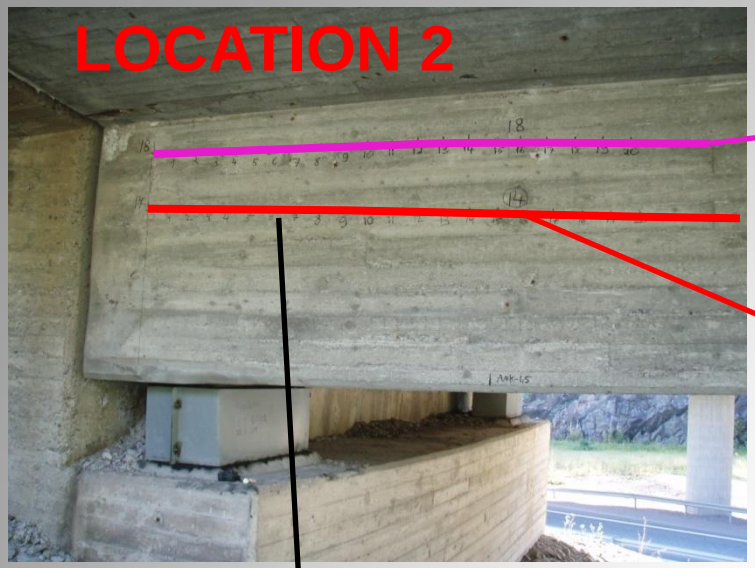
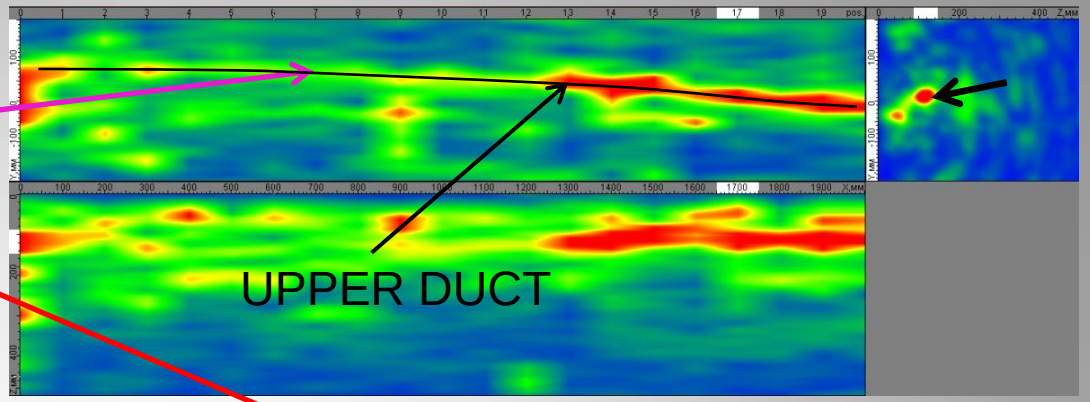
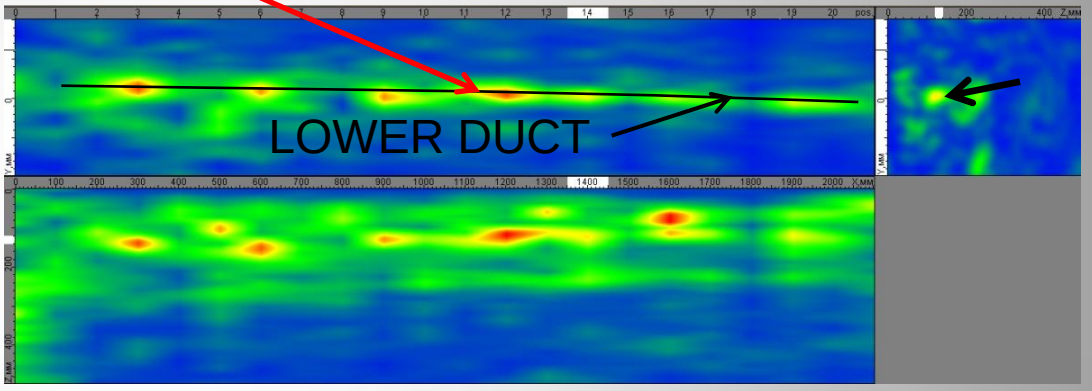
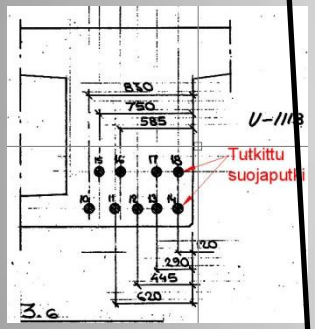
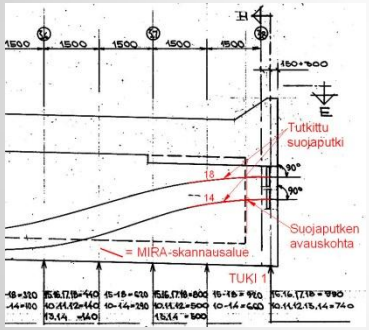
LOCATION 2

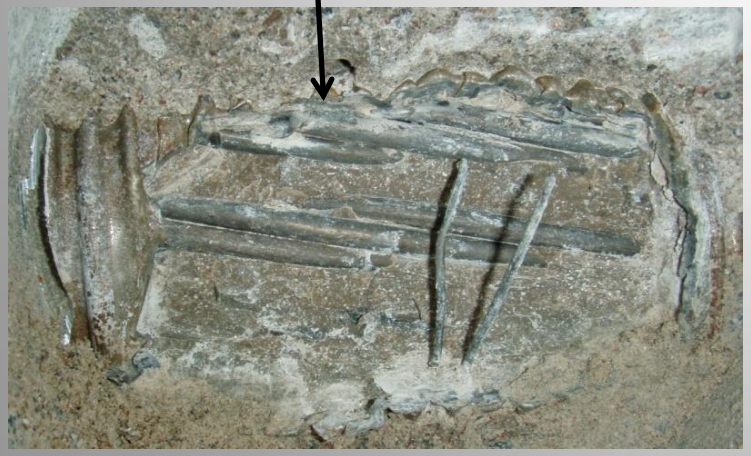












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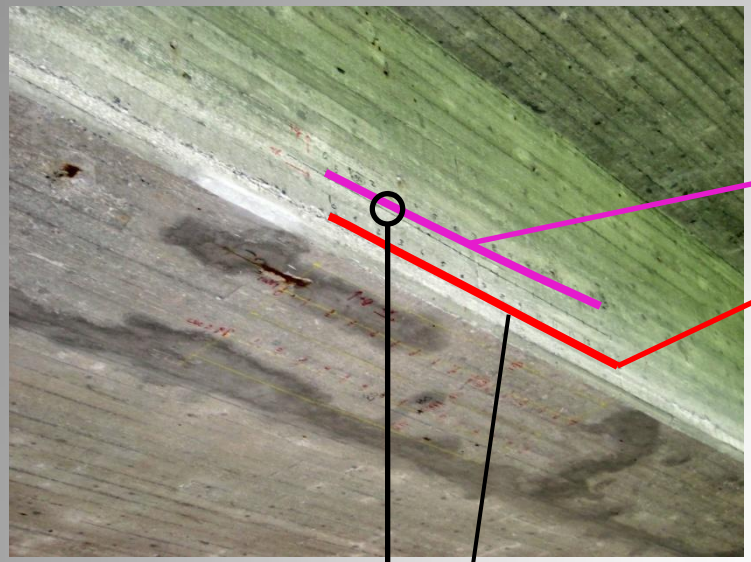
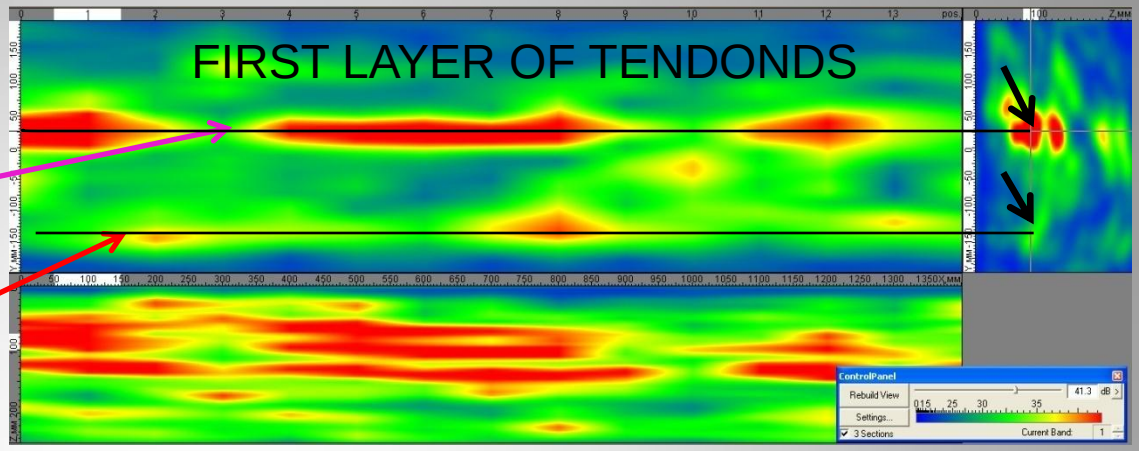
LOCATION 3 (middle of span)





OK
(CONFIRMED)

CONCLUSIONS

- The TOMOGRAPHER system is suitable for **evaluation of grout injection in ducts** (post-tensioned bridges).
- The inspection process: fast and accurate. Interpretation of results can be done on site.
- Additional usages of the Tomographer system :

  Condition evaluation of

  - nuclear plant protective concrete structure

  - regular reinforced concrete bridges etc.

THANK YOU

CONTACT DETAILS:

Guy Rapaport

Project Manager, Civil Eng. (Tech. University)
Infrastructure & Transport Service Area
Bridge Engineering

D +358 20 755 7258
M +358 40 824 5622

guy.rapaport@ramboll.fi
www.ramboll.fi

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