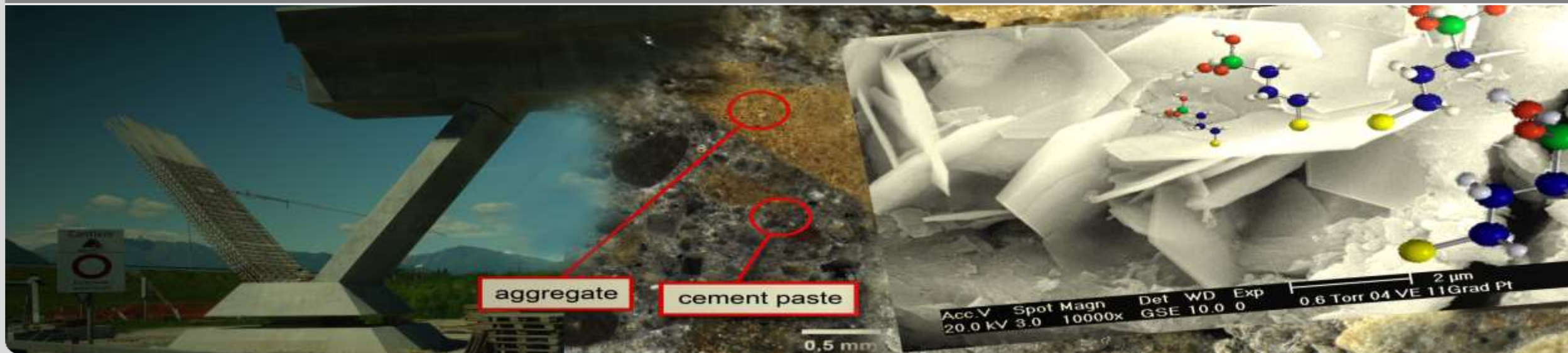


Heritage compatible and cost saving restoration of a historical railway viaduct

A. Gerdes, Scientific Director, KIT Innovation Hub Prevention in Construction





Laufenmühlen-Viaduct

- Build in 1911/12 with a length of 160 m
- First application of reinforced concrete for railway bridges in the state of Baden-Württemberg
- In 1980, Deutsche Bahn stopped passenger transport
- 1992 the viaduct is placed under monument protection
- In September 2000 the Schwäbische Waldbahn GmbH was founded and in 2010 put into operation as a tourist railway operated with historic steam and diesel vehicles
- Visible concrete damage makes it necessary to investigate the viaduct
- Development of a restoration concept for the rehabilitation of the viaduct



Cracks



Efflorescences



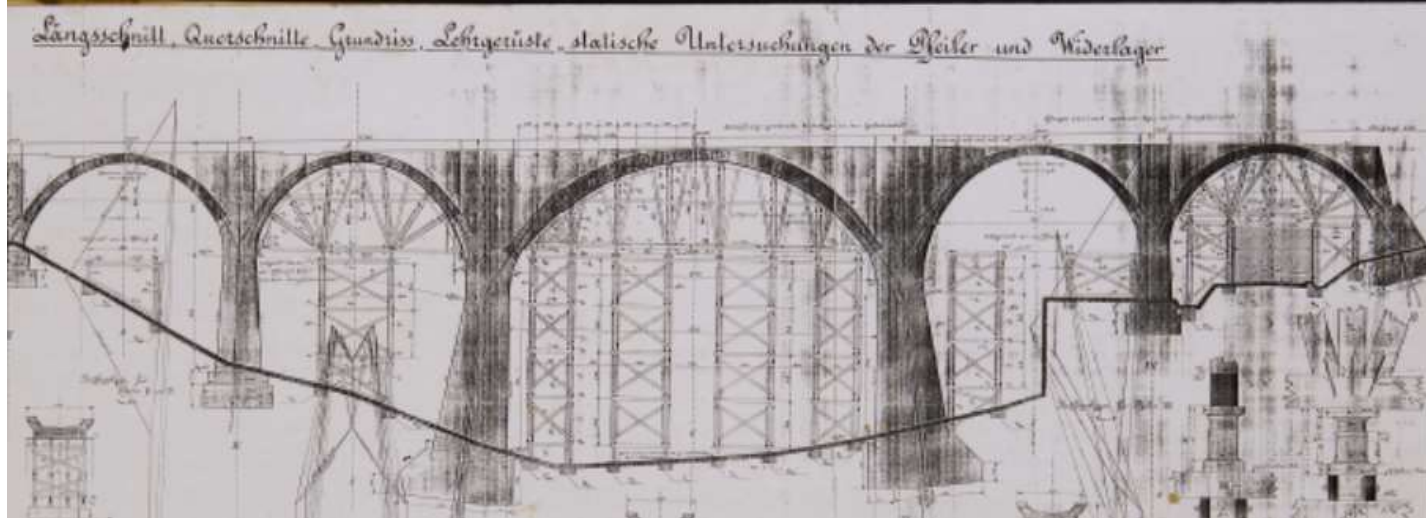
Old repair patches



Corroding reinforcement

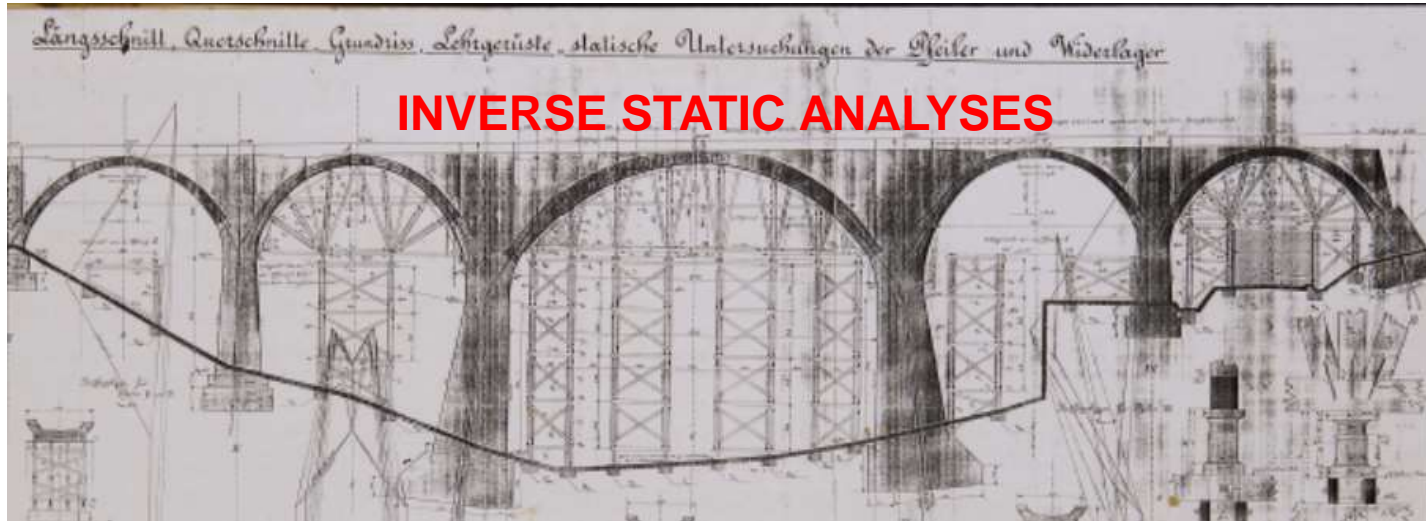
- Visible damages to the structure
- Survey delivers no information about the integrity of the structure
- ➔ **Planning a repair on the basis of this data leads to a high risk with regard to technical success, costs and long-term performance.**
- Use of sophisticated and nondestructive methods for the investigation of structures is a basic requirement in order to obtain a realistic view of the existing structure
- Testing of material samples in the laboratory is also necessary for the development of a repair concept
- ➔ **Planning on the basis of material properties leads to a significant improvement in the quality of repair work**

Original repair concept based on simplified construction analysis



- Determination of the compressive strength of drill cores → very low values (static calculations: - 2.5 N/mm²)
- Suspension of railway operation
- Production of new concrete-made bridge arches made to support the old arches
- In this case the Laufenmühlen Viaduct will no longer be a monument
- Calculates repair costs: 3.2 Mio. €

New approach: Scientific based concept for repair concept based on high sophisticated construction analysis

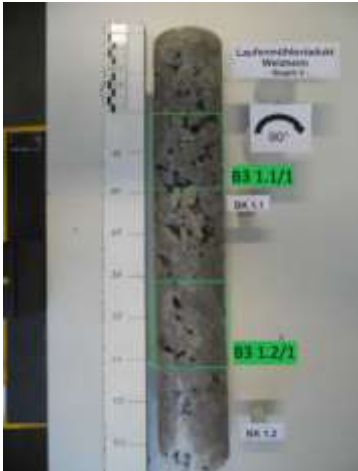
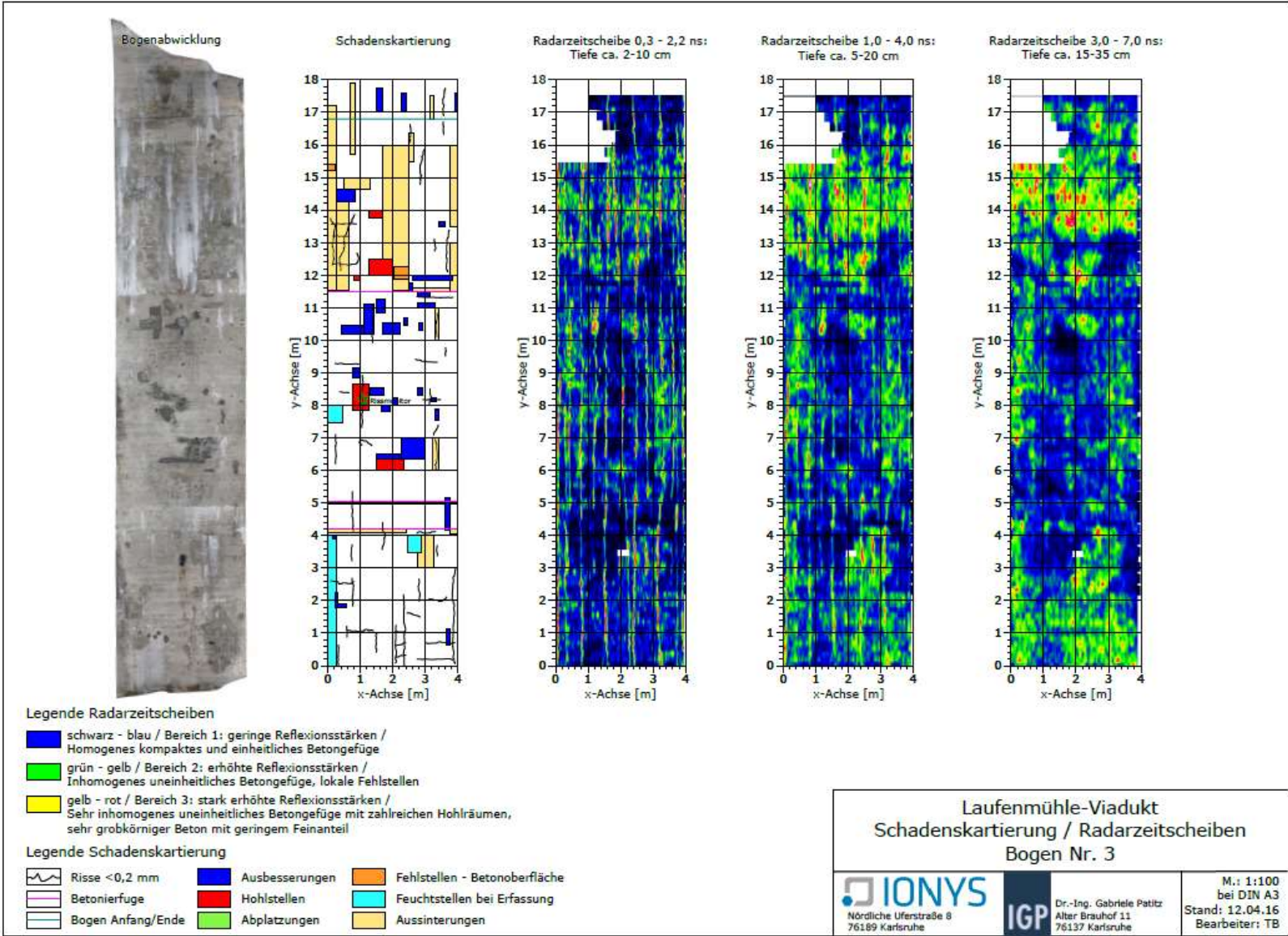


CONCEPT FOR THE INVESTIGATION OF THE LAUFENMÜHLEN VIADUCT

- Detailed survey of visible damage
- Radar examination of the arches
- Material investigations on drill cores taken from the arches
- Comparison of the test results as a basis for the repair concept
- Evaluation of repair methods
 - technical aspects
 - costs
 - compatibility for the environment and monument character



Laufenmühlen Viaduct – Results for Arch No. 3



- Repair of structural defects and cracks
- Preliminary tests for injection with "normal cement" or "ultrafine cement" respectively
- Performing a test injection to determine the drill grid (e.g. distance 25 cm), drill hole diameter (e.g. 18 mm), drill packer type, injection system type
- Execution of works according to the damage mapping
- Sealing the boreholes with mortar of matching colour
- Documentation with internal and external monitoring



„Highlights“ of the rehabilitation





Laufmühlen-Viaduct

■ Challenge

After incomplete preliminary investigations and static calculations based on these, a repair concept had been developed for the structure, according to which the existing arches were to be supported by modern concrete arches, which would have been costly, unsustainable and would also have led to a loss of the monument character.

■ Project

Development of scientifically based analysis and repair concepts.

■ Approach

Using modern analysis methods, the building status was recorded over the entire area. The requirements for the refurbishment were determined with an inverse static calculation and its success was checked by a quality control. The costs were thus reduced from the planned € 3.2 million to € 2.2 million, and the planned construction period was met.

■ Duration

01.09.2016 – 31.12.2018