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ICRI 2023 Fall Convention

STRUCTURAL HEALTH MONITORING TECHNOLOGIES FOR THE BUILT ENVIRONMENT

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InfrastructureTek

ICRI CONCRETE REPAIR
Restore | Repurpose | Renew
35th YEAR ANNIVERSARY

Revolutionary Smart Building Technology

Topics

- The case for Structural Health Monitoring
- Structural Health Monitoring Technology
- Case Studies – Bridge, Parking Garage, Historic Building

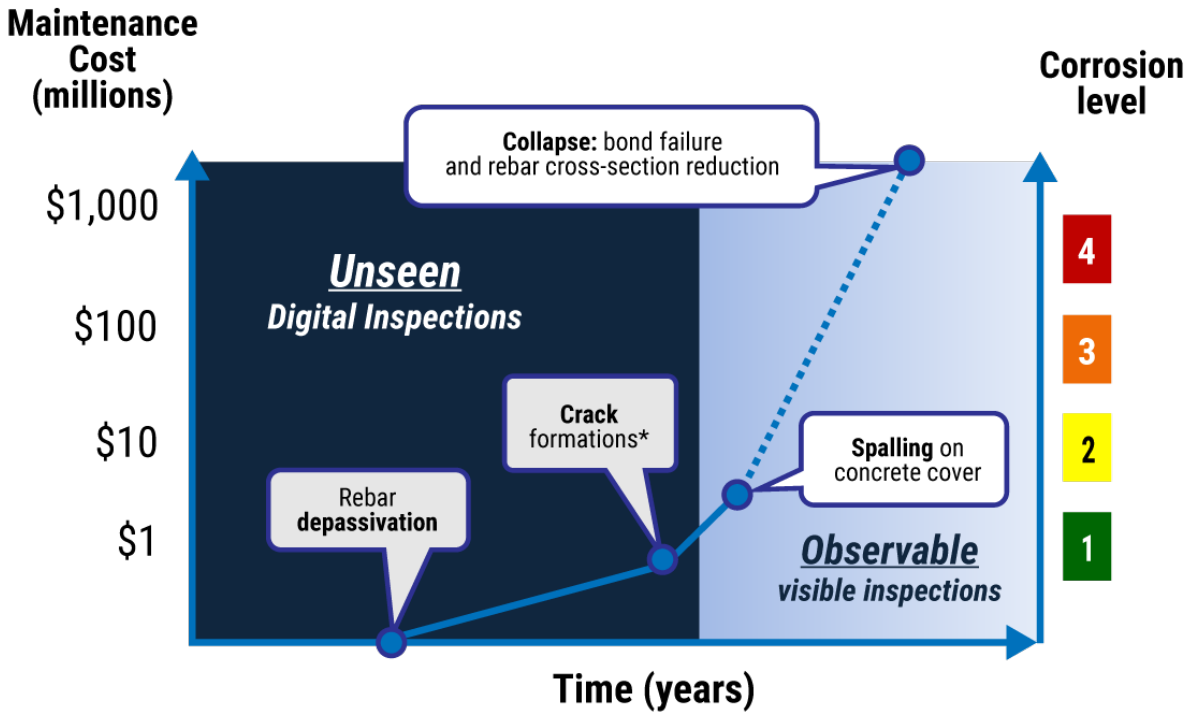
The ideas expressed in this ICRI hosted webinar are those of the speakers and do not necessarily reflect the views and opinions of ICRI, its Board, committees, or sponsors.

Why Smart Building Technology

- Recent structural failures
- Improve sustainability and resiliency in our infrastructure
- Early detection of damage can save **$$$**
- Data acquisition to improve **Safety** and mitigate **Risk**

Structural value preservation, safety, and sustainability through NB-IoT early damage detection

- Traditional condition assessments are popular but labor intensive.
- Traditional condition assessments have limited success in detecting early corrosion activity.
- Because the rebar corrosion can go undetected, there is an order of magnitude increase in rehabilitation costs between early-stage detection and later detection.



Invisible and observable corrosion process stages

The Technology behind the Sensors

- Require no batteries or external wires
- RFID technology (passive & active)
- Accessible manually or remotely
- Lifetime of over 70 years
- Allows effective lifecycle monitoring
- Automatically monitor the structure's internal health long before damage manifests in costly and disruptive rehabilitation.

Technologies for Sustainability and Resilience

- ✓ **Wireless Technology**: No wires protruding from the concrete member.
- ✓ **No external power source is required**: The energy is induced from the outside (RFID) via a gateway or a handheld reader.
- ✓ **Real-Time Data Collection**: Key parameters are continuously measured and recorded by the sensors.
- ✓ **Simple Installation**: Sensors are fully encased in new and existing concrete with a lifetime of over 70 years.

Health Monitoring Sensors

- **Humidity Sensors:** Measure the electrical conductivity and temperature within the concrete.
- **Corrosion Sensors**: Placed over the reinforcing steel before or after concreting. A special sensor wire is routed around the sensor body, which is destroyed by corrosive influences.

Wireless Concrete Sensor Solutions

Sensors are passive and require no direct energy.

- Sensors are power induced from the outside via a gateway or a handheld reader (RFID).
- Sensor data are acquired and transmitted to the Data Hub.
- Data can be read out on-site with a hand-held reader or can be automatically transmitted using a fixed gateway.
- Results are displayed in dashboards and customized reports on the I-Tek monitoring platform.

Gateways to the Cloud

The reader meets the following requirements:

- **Fixed gateway**
  - Data acquired and transmitted to the cloud
  - Reading Range of 6 inches
  - Stable and waterproof
  - Power source (battery, solar, wired)
  - Can be maintained – on the outside of the structure
  - Adjustable data transmission frequency

Gateways to the Cloud

The reader meets the following requirements:

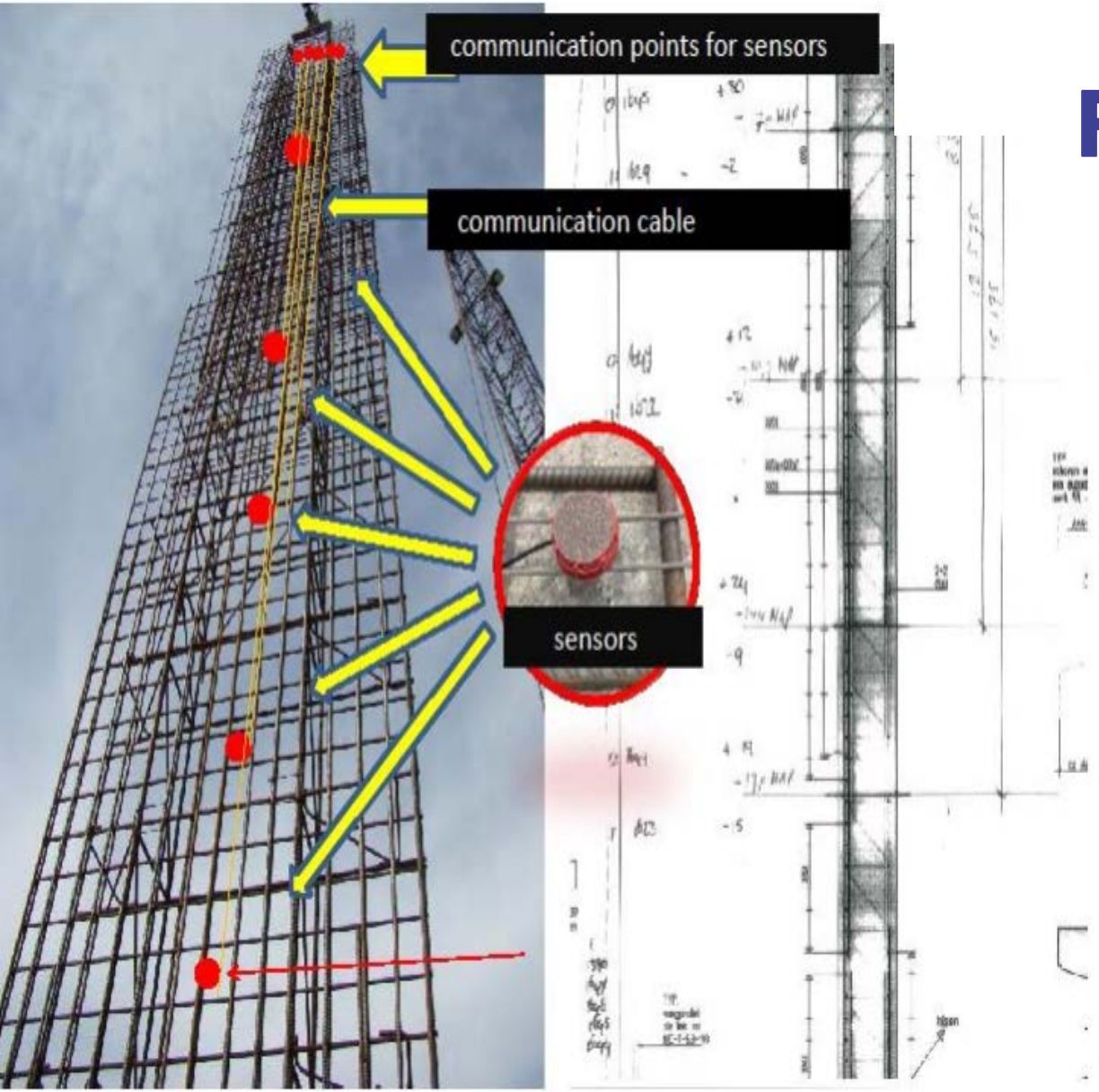
- **Hand-held Reader**
  - Reading Range of 6 inches
  - Small and durable
  - Store data or transmit to the cloud



SENSORS APPLICATIONS



NEW or EXISTING Bridges, multi-story parking garages, buildings, tunnels, stadiums, pre-stressed/ post-tensioned structures, Institutional Buildings, ...



Remote Sensor Locations

- Sensors can be placed almost anywhere in the structure
- Antennae inside or outside the concrete transmit data to the gateway.

Installation Methods

- New construction – Installed before concrete placement
- Repair – Before placing concrete patch material
- Existing Structure – placed in a core hole

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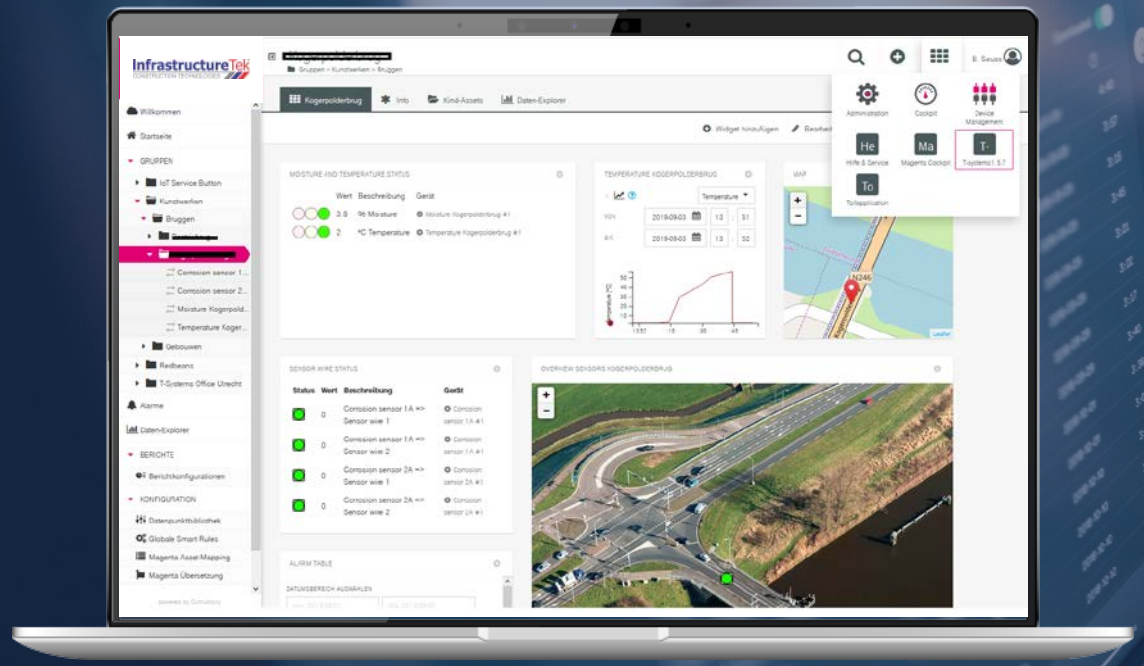
Online Monitoring



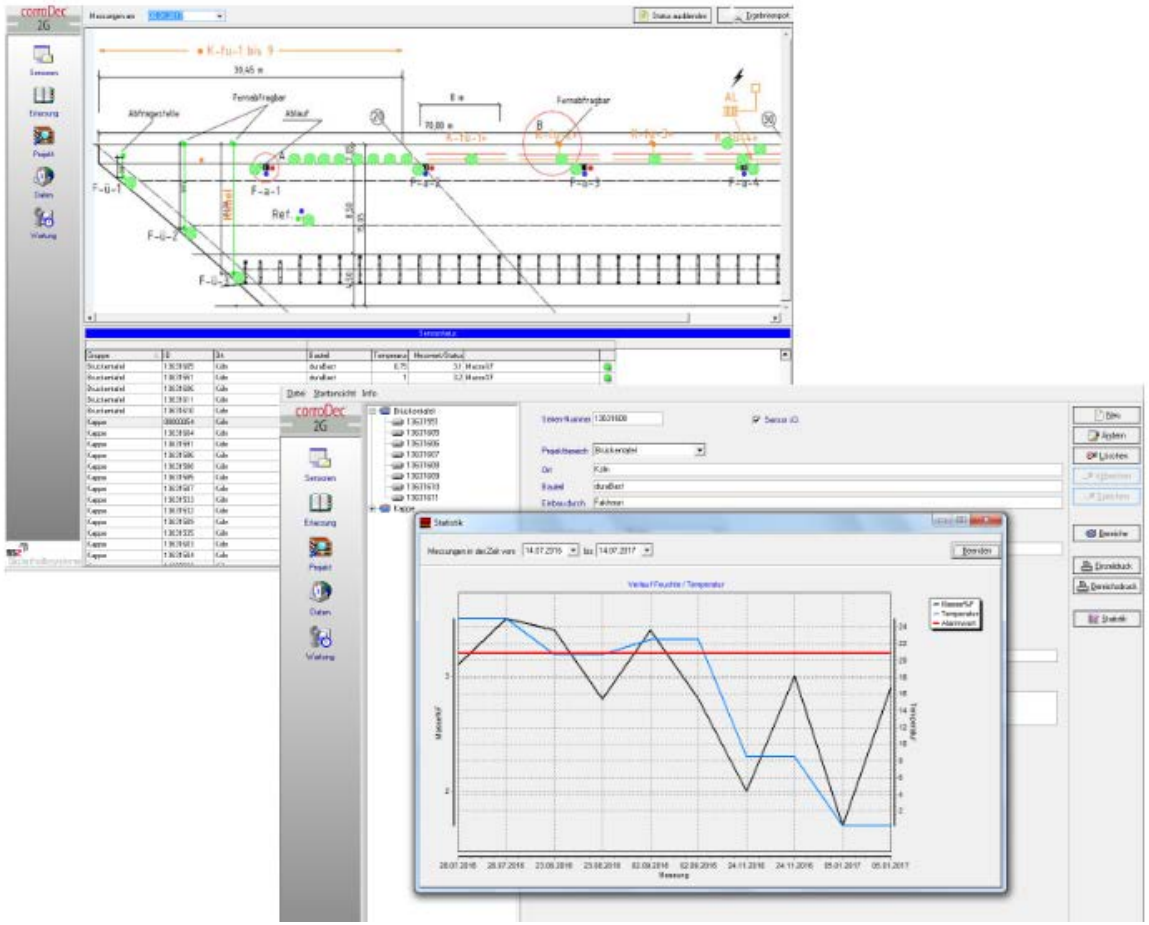
Customizable Dashboards:

- ✓ Data transmission via NB-IoT technology enables cost-efficient online monitoring.
- ✓ Secure/encrypted data transfer (proprietary conversion)
- ✓ Monitoring by owner, manager, consultant
- ✓ Data stored at data hub

Web-based portal

Server infrastructure, Data hub, data conversion, and web-based data visualization:

- Web-based or via interfaces
- 24h online available
- Trend analysis
- Alarm function / Push notification
- Customizable dashboards
- Accurate real-time data display (corrosion and humidity levels).
- Multi-project usability/applicability
- Proprietary offline software is available.



Concrete Corrosion Monitoring – Case Study

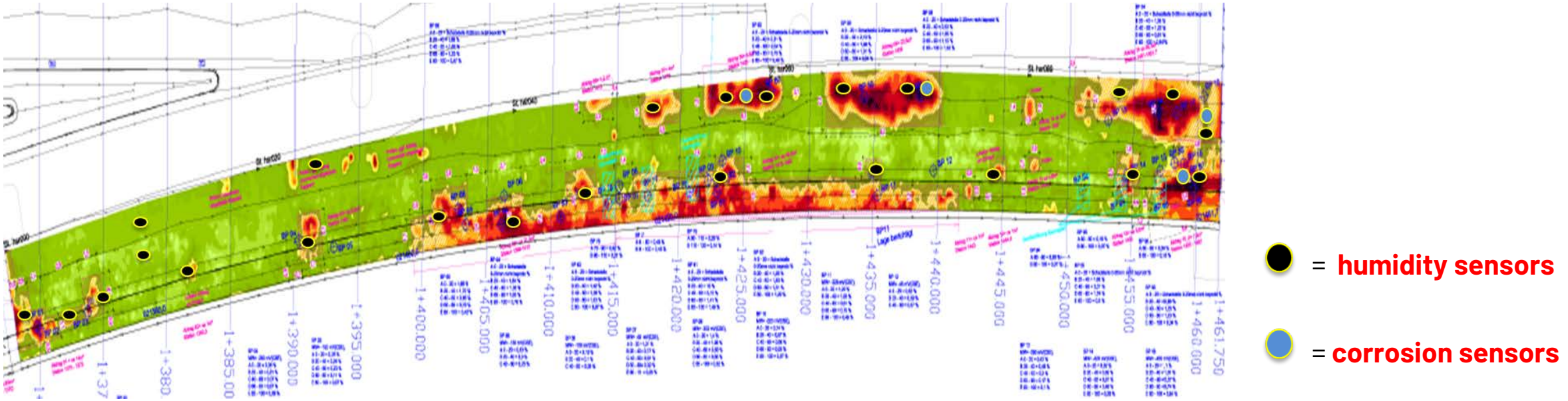
Smart bridge – city of Koblenz/Germany

- Realization of digital, sensor-supported, and proactive online monitoring (IoT) of corrosion and moisture events of a bridge structure during the repair.
- Customer: Public state road authority
- Building construction date 1972 <> 1975
- 46.000 vehicles / 24h including heavy load traffic
- All concrete surfaces of the bridge were repaired after sandblasting to remove massive chloride contamination

Challenge: Not only the quality of the repair works but also the future progress of damages should be monitored over the next 15 – 20 years on the estimated remaining usage period

Concrete Corrosion Monitoring – Case Study

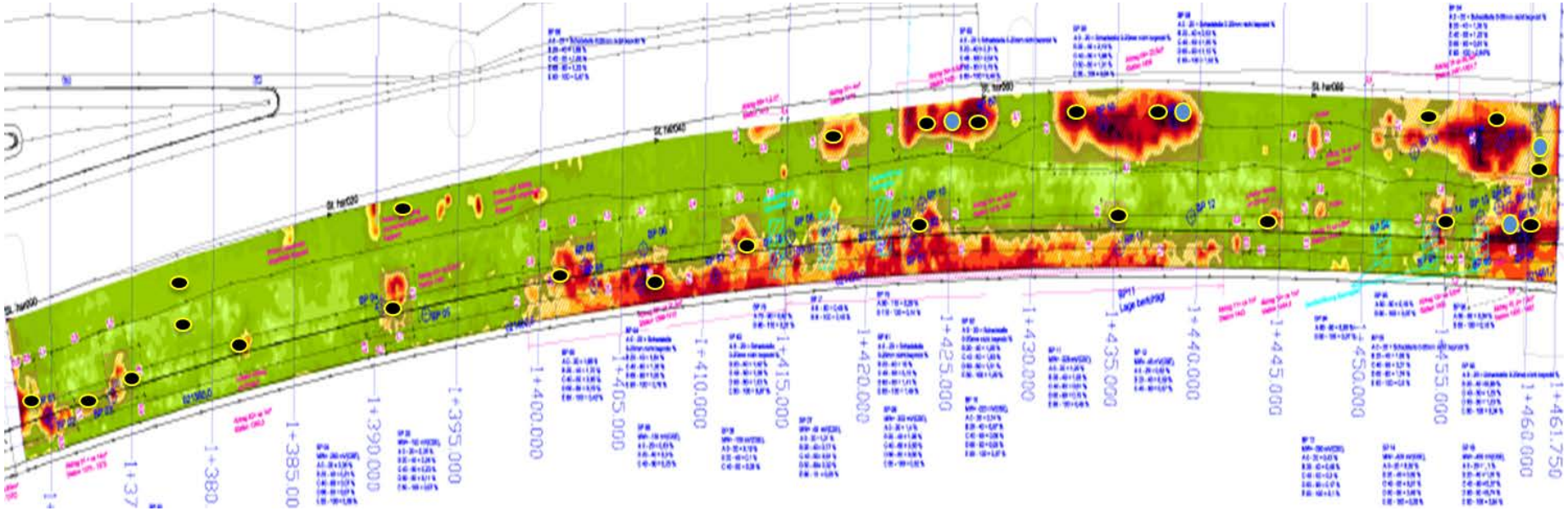
Smart bridge – city of Koblenz/Germany



Based on the potential field plans, a warning system was designed and implemented to monitor the corrosion status and moisture development at critical points in the concrete. The temperature inside the concrete is measured as well and acts as a further lead indicator to early identify and avoid potential damage.

Concrete Corrosion Monitoring – Case Study

Smart bridge – city of Koblenz/Germany



● = **humidity sensors**

● = **corrosion sensors**

Focus:

- Areas with the highest contamination or the highest static risk potential
- Bridge drain locations
- Bridge joints
- PT anchor blocks
- Control reference points

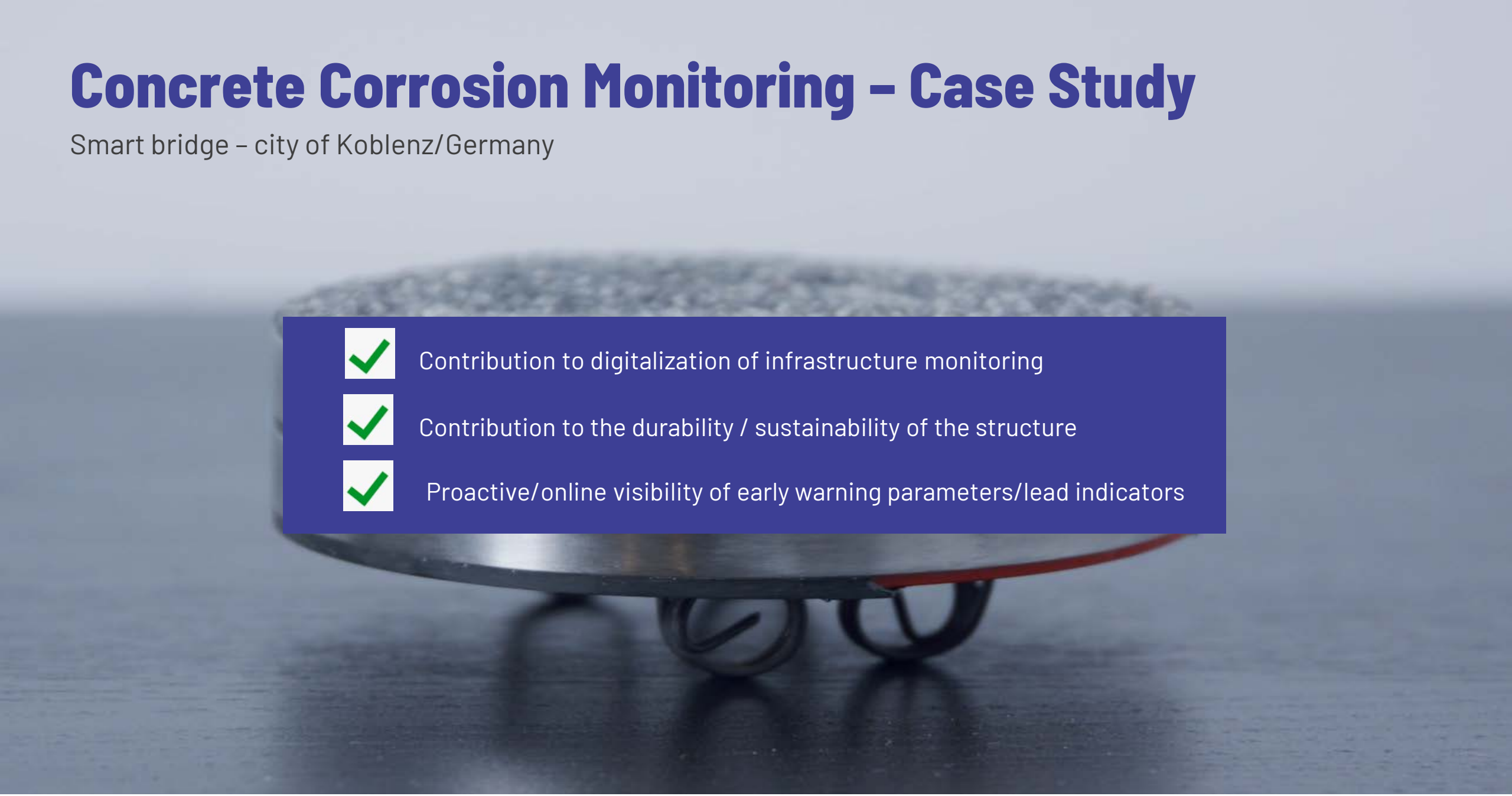
Concrete Corrosion Monitoring – Case Study

Smart bridge – city of Koblenz/Germany

- A sensor early warning system for monitoring the corrosion behavior and moisture in the concrete was successfully installed.
- The data is read by our gateway and transmitted to the cloud.
- Meaningful and effective monitoring requires the measurement of lead indicators over a long period of time.
- CorroDec is a non-destructive method to monitor the condition of the concrete over its lifespan.
- **Total repair costs for the bridge: 27.000.000 €**
- **Budget for the monitoring system: 90.000 €**

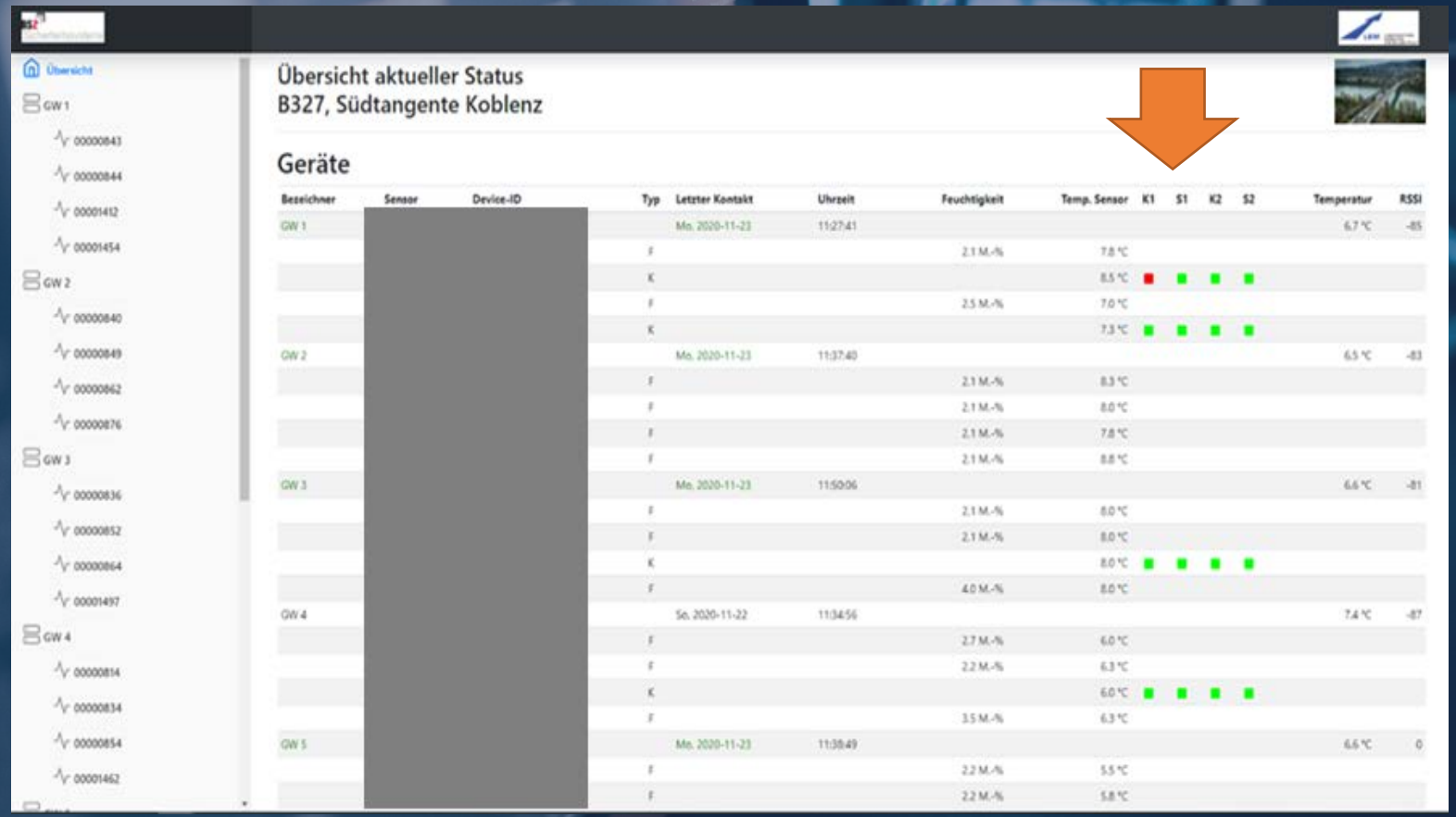
Concrete Corrosion Monitoring – Case Study

Smart bridge – city of Koblenz/Germany



- ✓ Contribution to digitalization of infrastructure monitoring
- ✓ Contribution to the durability / sustainability of the structure
- ✓ Proactive/online visibility of early warning parameters/lead indicators

Web-based portal - Corrosion

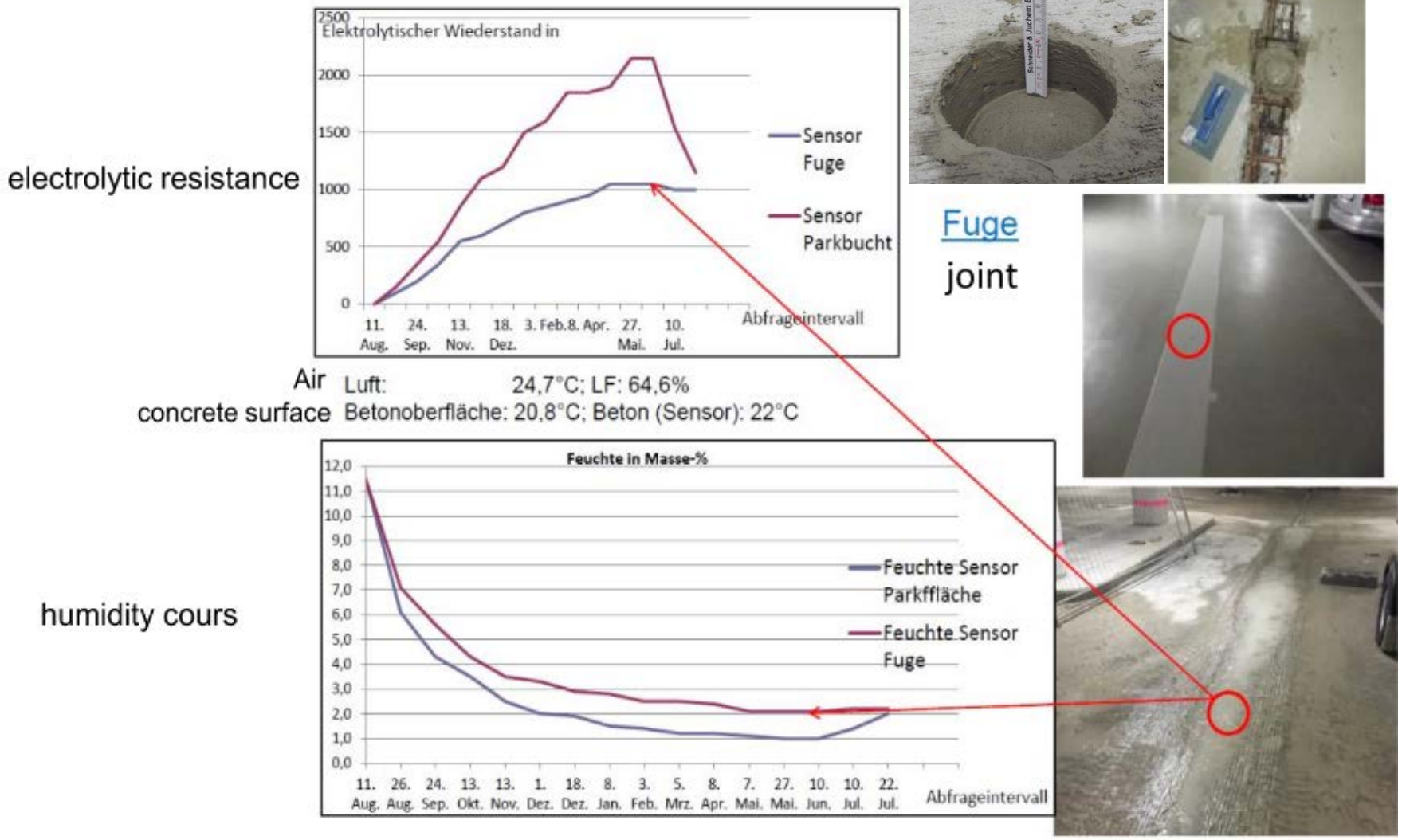


Web-based portal - Corrosion

Side-info: Only weeks after repair works
2 potential construction issues could be detected ONLINE letting the property owners fix them during the contractor's warranty period

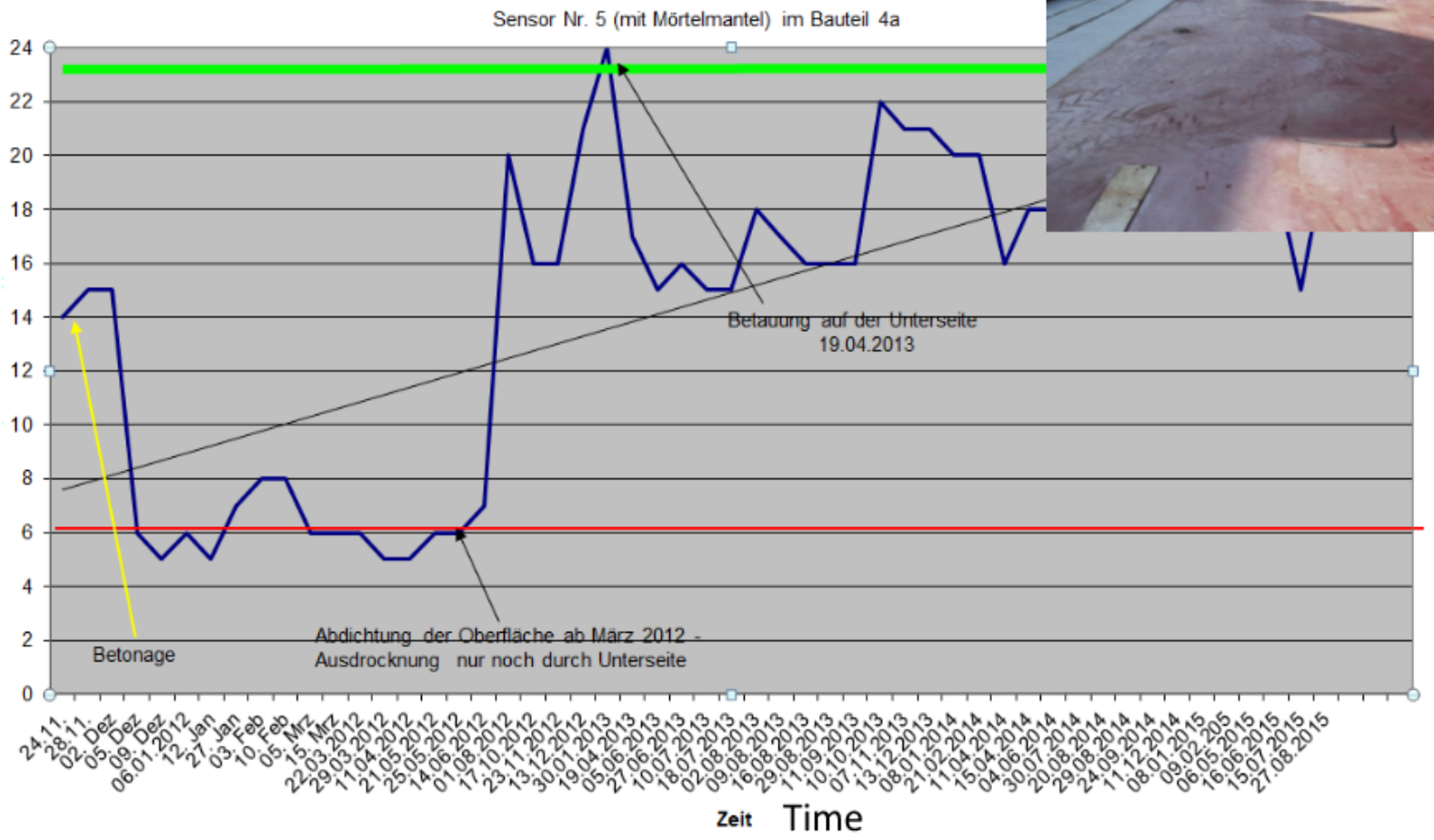
Real Project Examples

Existing structure
A repaired Parking garage.
Task: Humidity monitoring



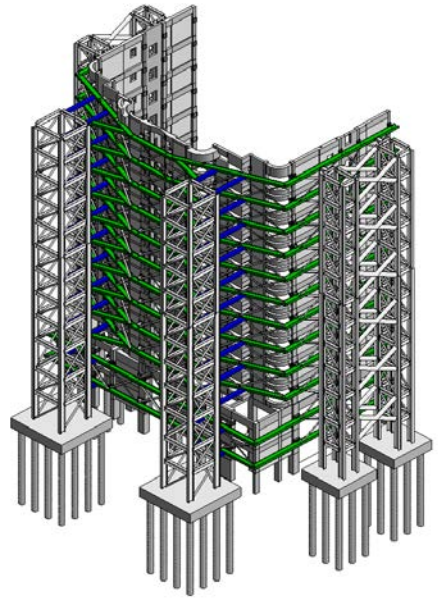
Real Project Examples

New structure- Parking garage.
Task: Humidity monitoring



Historic Preservation – Miami Beach

- Miami requires historic preservation for new developm
- KLINE is restoring the historic façade and designing the replacement structure.
- I-Tek will be installing corrosior and humidity sensors into the existing concrete columns and beams.



Looking to the Future of Smart Building Technology

- Ability to collect enormous amounts of data
- Use analysis algorithms and statistical modeling to identify patterns and detect anomalies.
- Use AI algorithms to analyze historical data, and environmental factors to predict future degradation and inform owners on how best to build new and preserve existing structures.

Questions?

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