Numerical Evaluation of ROC of Potential Mapping

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Abstract

The corrosion of the reinforcement is often the major cause for the end of service life of reinforced concrete structures. Cracks due to corrosion are the first visible sign of the deterioration process. But in this stage the deterioration process is advanced. Now, it is too late for a cost-effective and pro-active maintenance strategy. Once the corrosion process is initiated, corroding areas can be detected non-destructively through potential mapping. So, the inspection results coming from potential mapping are of vital importance to ensure the safety and reliability of our infrastructure.

The crucial factor for successful corrosion detection is a good probability of detection of potential mapping. But the knowledge about the accuracy of the measurement method itself is not sufficiently well known. The problem is the knowledge about the true corrosion condition state, which is only identifiable by replacement of concrete cover. No owners will agree to open a whole structure for evaluating the accuracy of an inspection method. In order to solve that problem an approach based on numerical models is pursued in this research.

The aim of the paper is the numerical analysis of the accuracy of the inspection method potential mapping. What are the advantages and disadvantages of the numerical analysis of probability of detection and receiver operating characteristics? What are the consequences for the measurement procedure in practice? Is it possible to derive recommendation for a suitable evaluation method of potential mapping?

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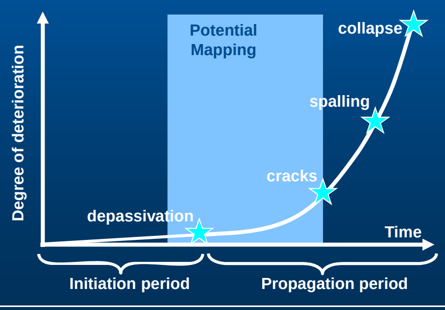
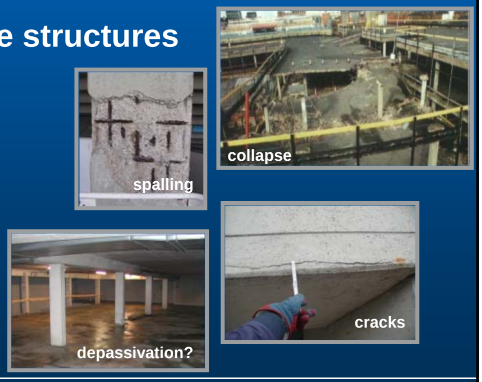
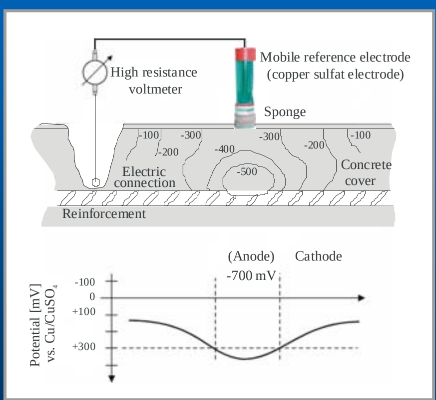
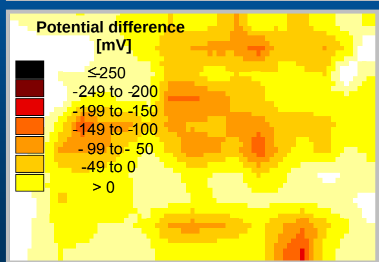
Life-time of reinforced concrete structures





Potential mapping





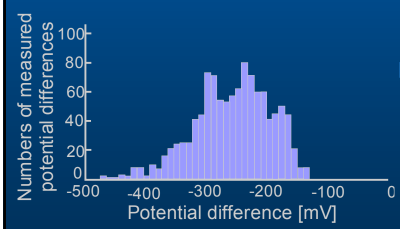
Updating service life prediction

$$\Pr(condition \mid inspection) = constant \cdot \Pr(inspection \mid condition) \cdot \Pr(condition)$$

?

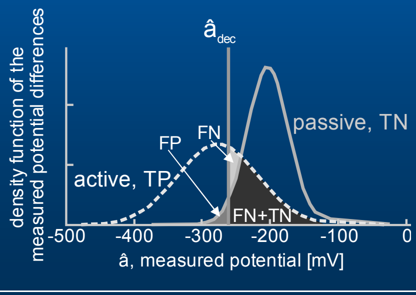
Initiation period $$Pr_f = Pr\left\{C_{crit} - C_{S,\Delta x} \cdot \left[1 - erf\frac{d_c - \Delta x}{2\cdot\sqrt{k_e \cdot k_t \cdot D_{RCM,0} \cdot t \cdot \left(\frac{t_0}{t}\right)^a}}\right] < 0\right\}$$

Evaluation of potential mapping

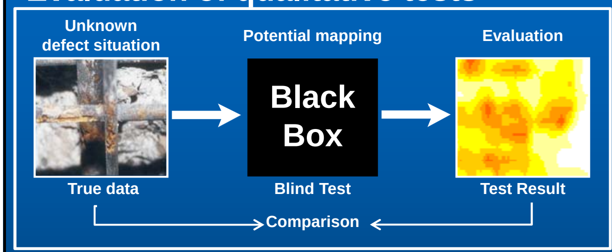


MLE

Maximum Likelihood Estimate



Evaluation of qualitative tests

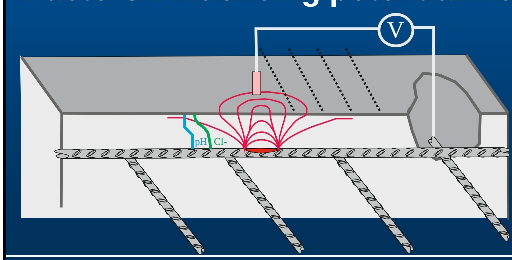


Problems:

- Replacement of concrete cover:
  - cost-intensive
  - time-consuming
- Identification of anode areas:
  - electrochemically impossible
  - visually too inaccurate

→ **Solution: Numeric**

Factors influencing potential mapping



Group A:
Expansion of the Potential field

Group B:
Electrokinetic effects

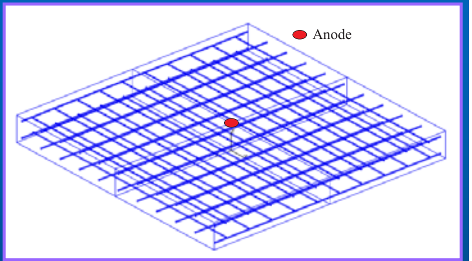
Group C:
Electrode potential

Group D:
Measurement procedure
Evaluation

Numerical Model

Input data:

- Section of a reinforced concrete plate
- Dimension: 2.0 x 2.0 m
- Diameter 12 mm
- 4 reinforcement layers
- Driving potential 380 mV
- Polarization curves according to Brem

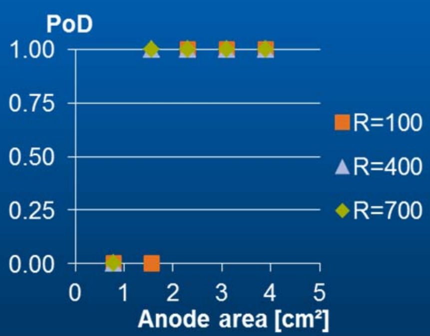


Variation:

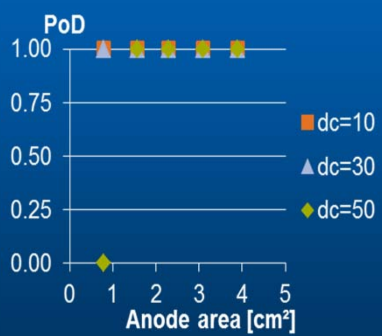
- Concrete cover: 10, 20, 30, 40, 50 [mm]
- Anode area: 0.78, 1.56, 2.3, 3.1, 3.9 [cm²]
- Concrete resistivity: 100, 400, 700 [Ωm]
- Grid size 5x5; 10x10; 15x15; 25x25 [cm²]
- Grid size combination

Hit/Miss Results: Plate

Variation of concrete resistivity
Grid size 15x15cm², d_c=50mm



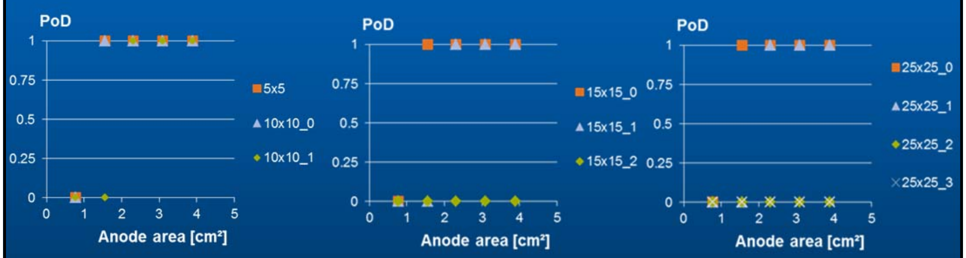
Variation of concrete cover
Grid size 15x15cm² , R=400Ωm



Is it possible to realize a PoD-Model with such a small database?

Hit/Miss Results: Plate

Variation of grid size
R=400 Ωm, d_c=50mm



Conclusions:

- Grid size has major influence on the PoD
- Low concrete resistivity leads to poor detectability
- The concrete cover has only an impact in combination with low resistivity

Outlook/ Question:

- Describing the PoD with the â vs. a model:

How to implement Noise/Variance in the simulated data?

- Expand of data base

How to combine experimental data with simulated data?

- Validation on existing structures
- Investigation of additional geometries, e.g. column
- The grid size can be determined based on the accuracy requirements of the customer
- Spatial updating of the service life prediction with inspection data coming from potential mapping
- ROC of potential mapping