

# Concrete Test Specimen for NDE Reliability Demonstration

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## Abstract

POD analysis is only as reliable as the data on which it is evaluated. And the data are only as good as the system from which they are derived. The capability of an NDE system should be tested under representative application conditions. The experimental design reflecting the application condition should consider factors effecting the measurement, represent real inspection environment and include flawed and unflawed specimens. Although there are general guidelines for designing experimental setups specific instructions for capability demonstrations of NDE in civil engineering (CE) are missing.

For the last century the dominant construction material in CE is (reinforced) concrete. Typical applications of NDE in the field of CE are detection of cracks, honeycombs, spalling, metallic reflectors, reinforcement corrosion, cracks in pre-stressed wires and so on. Suitable NDT techniques for evaluation are, for instance Radar, ultrasonic, impact echo, acoustic emission, modal analysis, electrochemical methods, etc.. Each measurement technique associated with its specific application experiment has to be designed individually for capability demonstration.

This is not an easy task since concrete is a highly complex material. Concrete is a composite material composed of coarse aggregates and a porous cement matrix. Each cementitious mixture is unique due to individual compositions with variations in cement type, water-to-binder ratio, used aggregates, admixtures and additives. Later on it is not possible to identify the concrete composition properly without any documentation. Additionally, concrete changes its properties over time due to on-going hydration processes. When concrete is exposed to field application the moisture content varies accordingly and environmental attacks such as freeze-thaw or chlorides can impair the surface condition and structural integrity. Basically, concrete is subjected to load-dependent and load-independent deformations which can cause unwanted crack formations.

Since test specimens should reflect the structural types that the NDE process will encounter in application, basic agreements with respect to concrete type, geometry, surface condition, storage condition and especially flaw implementation has to be discussed. Therefore, intensive discussion between operators, structural engineers, material engineers and NDT experts is needed to elaborate a guideline for designing concrete specimen for NDE reliability demonstration in civil engineering.



## Motivation

Dominating construction material:

- Reinforced Concrete

Typical tasks:

Detection of

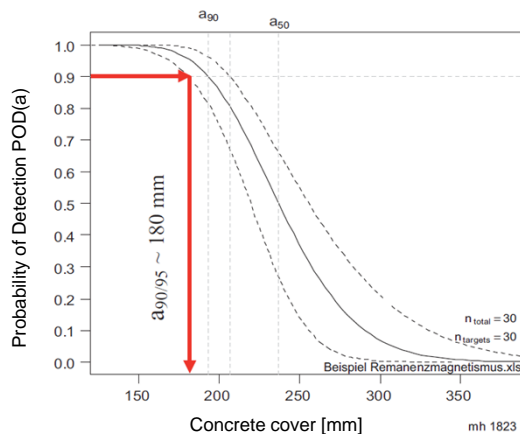
- concrete cracks
- concrete spalling
- delamination
- honeycombs
- reinforcement corrosion
- cracks of pre-stressed wires/tendons
- incomplete grouted pre-stressed wires
- etc.

- High demand on NDT in civil engineering

➤ **Reliability?**

## Examples of POD in Civil Engineering

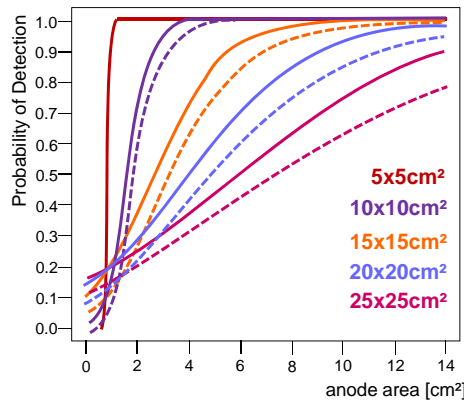
Fracture detection of tendon wire in dependence of concrete cover



Ref: A. Taffe, S. Feistkorn: Methoden zur Gütebewertung von ZFPBau-Verfahren, Beton- und Stahlbetonbau 108 (2013), Heft 4

## Examples of POD in Civil Engineering

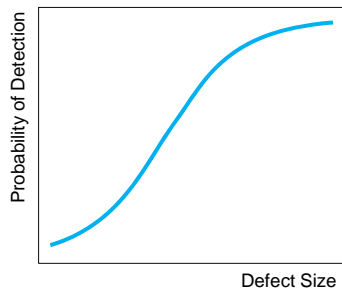
Corrosion detection in reinforced concrete structures with half-cell potentials



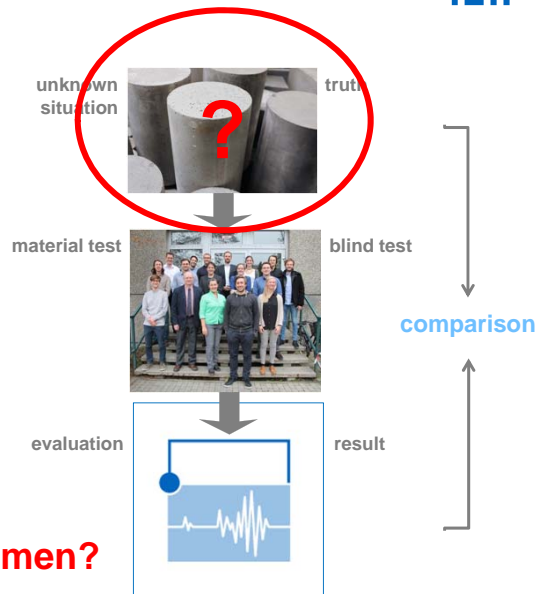
Ref: Kessler, S.; Gehlen, C.: Reliability evaluation of half-cell potential measurement using POD, Journal of Infrastructure Systems 23 (2), 2017

## Motivation

Probability of Detection:

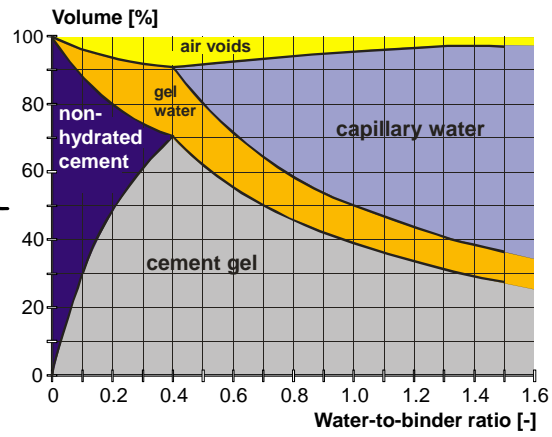
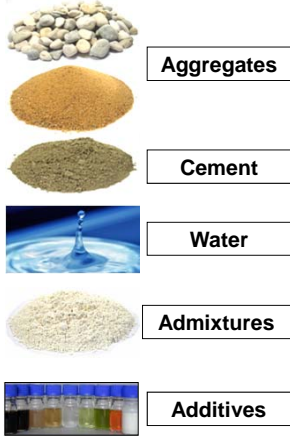


➤ **Concrete test specimen?**

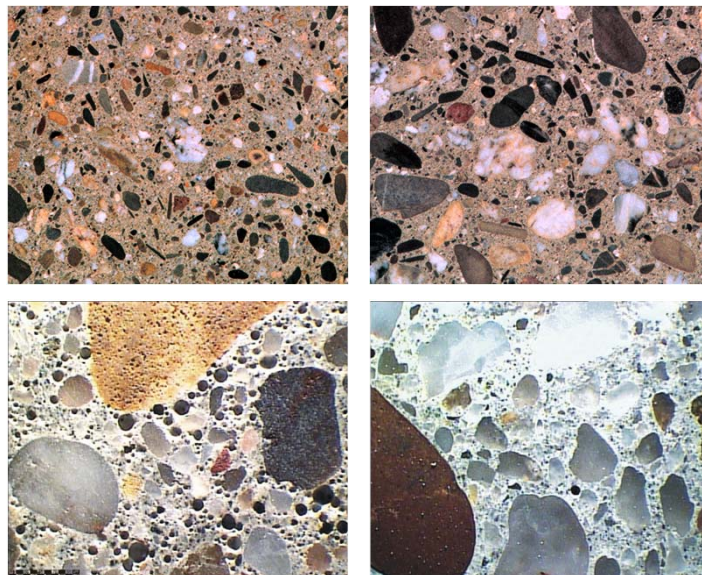


# Concrete

What is concrete?



# Concrete



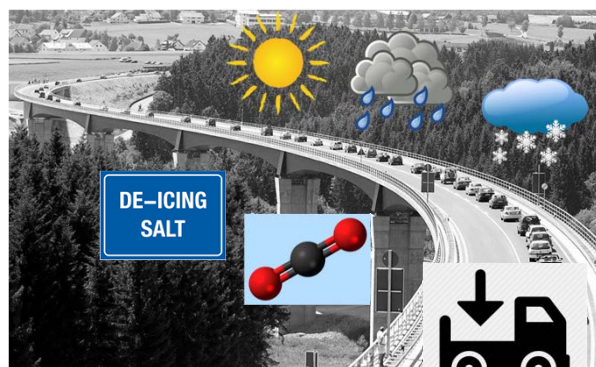
## Concrete test specimen

Challenges:

- Each concrete batch differs from one another even made with same composition/ same material
- Once the concrete is done and the composition sheet is lost it's nearly impossible to reconstruct the composition from the hardened concrete
- Concrete changes constantly over time
- Most properties are moisture-dependent
- Most properties are temperature-dependent

## Concrete test specimen

- Each reinforced concrete structure is unique
  - Static system
  - Used material
  - Exposure
  - Load history



- **Guideline for concrete test specimen for NDE reliability demonstration**

## Concrete test specimen

DEPARTMENT OF DEFENSE  
HANDBOOK  
NONDESTRUCTIVE EVALUATION SYSTEM  
RELIABILITY ASSESSMENT



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....For most NDE methods the **contractor should select alloys, material forms, and raw material processing** that represent the significant physical properties for the method being evaluated.....

....System evaluation is conducted considering the **range of materials** expected to be used in production.....

....**Surface condition** of the specimen may influence inspection signal-to-noise ratios. Final machining of the specimen should be consistent with final machining of the part.....

....To evaluate the inspection system in the **application environment**, these variables should be identified so that they can be fairly represented in the demonstration tests....

## Concrete test specimen

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....The test specimens should reflect the **structural types** that the NDE process will encounter in application with respect to geometry, material, part processing, surface condition, and, to the extent possible, target characteristics.....

.... **The specimen should be designed such that the targets can be inserted**, and the final geometry obtained by machining or other forming methods that will not change the target characteristics (size, shape, and orientation and intended location).....

....Since a single NDE process may be used on several structural types; multiple specimen sets may be needed in a reliability assessment. **The contractor should determine the characteristics of the test specimens and recommend the number of flawed and unflawed specimens.** All test specimens available to the contractor should be evaluated to determine if existing test sets meet the guidance of the reliability demonstration.....

## Outlook

Communication is needed between:

