Imprægnering af potentiel AKR-farlig beton

DTU Technical University of Denmark

RAMBØLL Bright ideas. Sustainable change.

Projektgruppen

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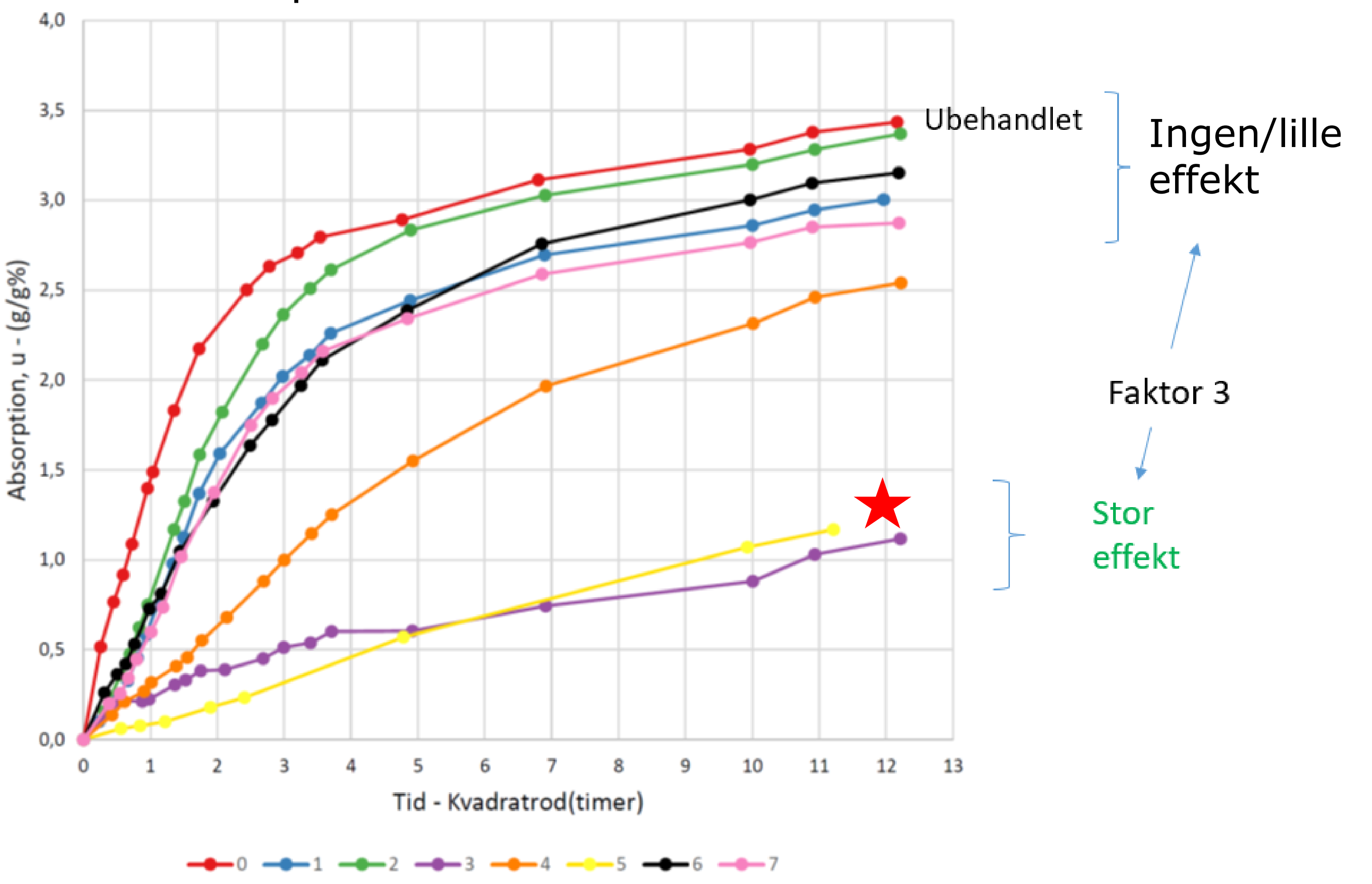
Agenda

- Tidligere undersøgelser (grundlag for valg af imprægnering)
- Alkalikisel reaktioner (AKR)
- Betonsammensætning
- Forsøgsopsætning
- Ekspansionsmålinger og visuel registrering
- Fugtmålinger
- Sammenfatning
- Konklusion
- Fremtidigt arbejde

Valg af imprægneringsmiddel

- Produkt udvalgt på baggrund af tidligere undersøgelser ★
- Silan imprægnering (velegnet til beton)
- Gel-konsistens (praktiske årsager)

Betonprøver nedsænket i vand



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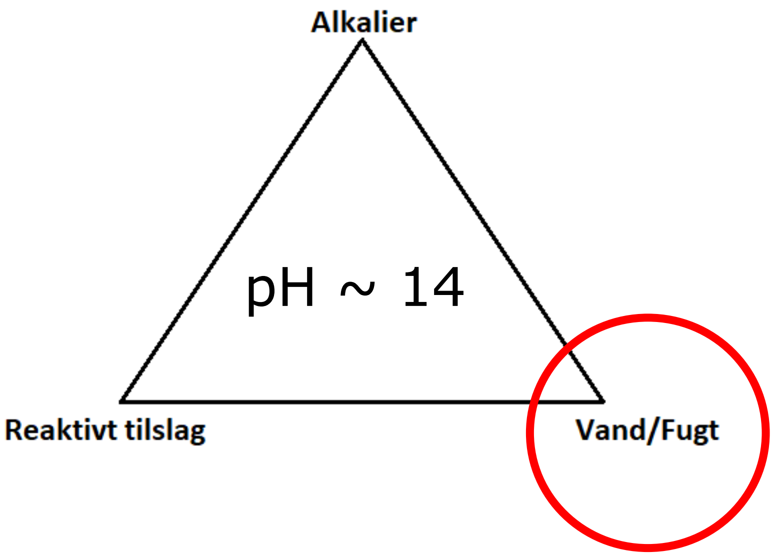
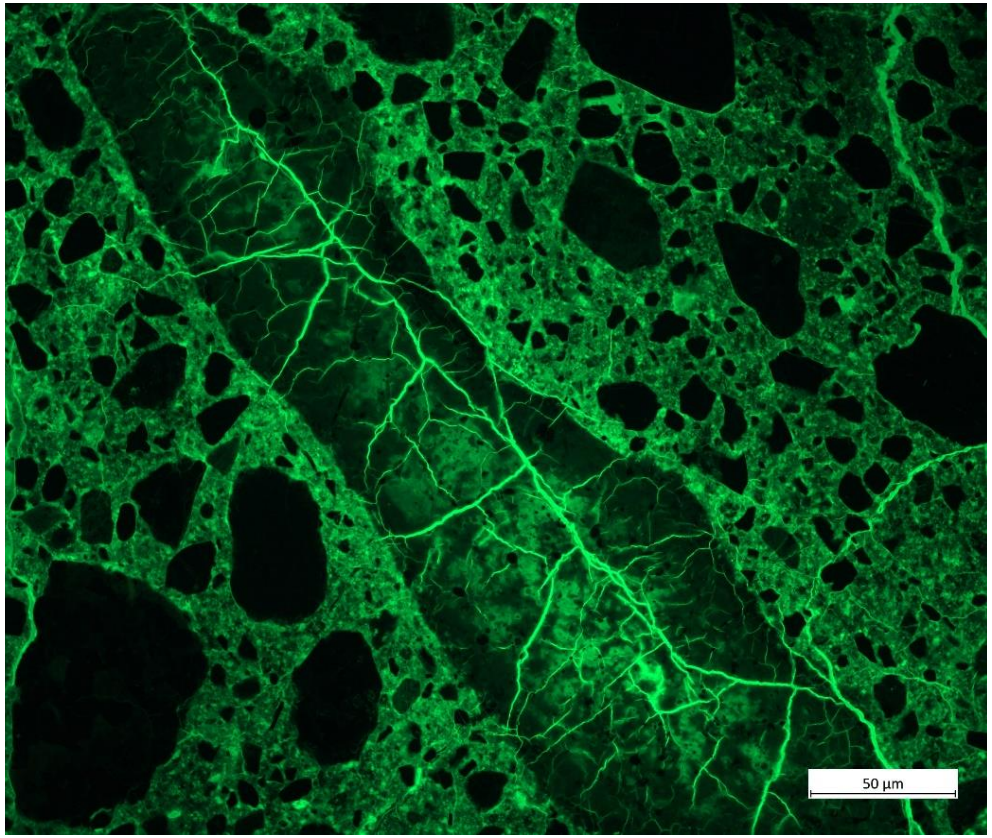
Generelle forudsætninger for AKR-farlig beton





Betonsammensætning

Mix 1

v/c-forhold = 0,45
Reaktiv
Ikke imprægneret
Alkali = 5 kg/m³

Mix 1

v/c-forhold = 0,45
Reaktiv
Imprægneret
Alkali = 5 kg/m³

Mix 2

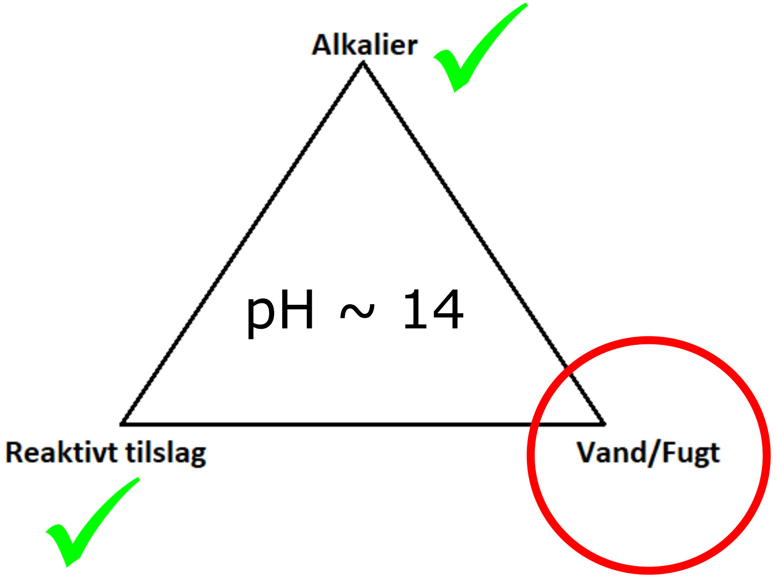
v/c-forhold = 0,55
Reaktiv
Ikke imprægneret
Alkali = 5 kg/m³

Mix 2

v/c-forhold = 0,55
Reaktiv
Imprægneret
Alkali = 5 kg/m³

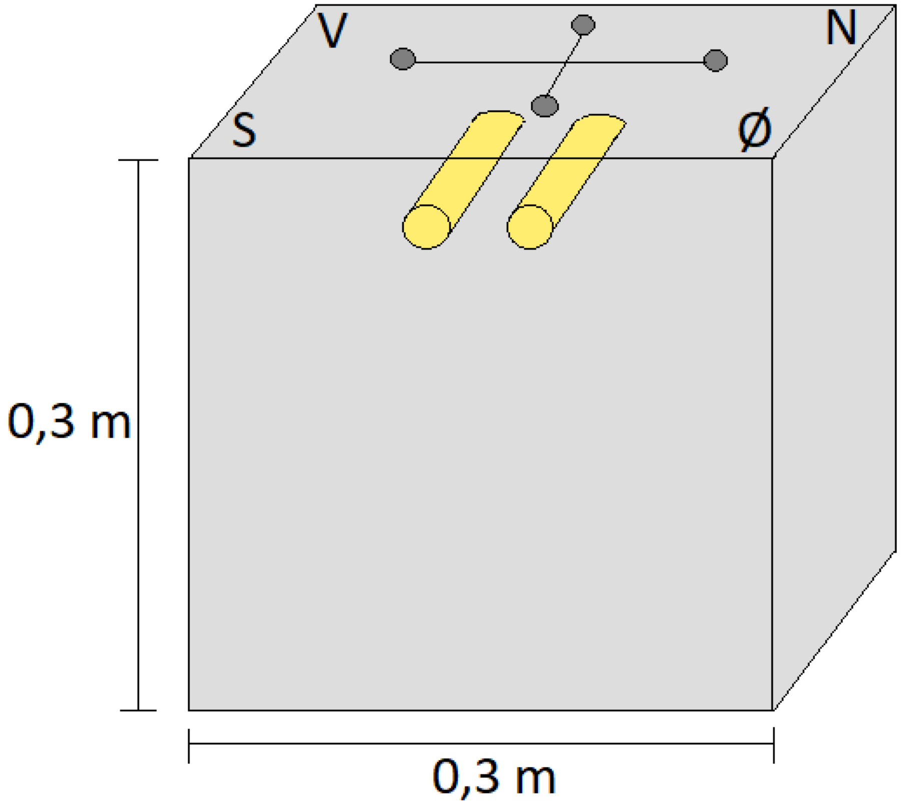
Generel betonsammensætning

- Cementindhold: 500 kg/m³
- Groft tilslag: Rønne Granit
- Fint tilslag (reaktivt): Bakkesand (Øde Hastrup)



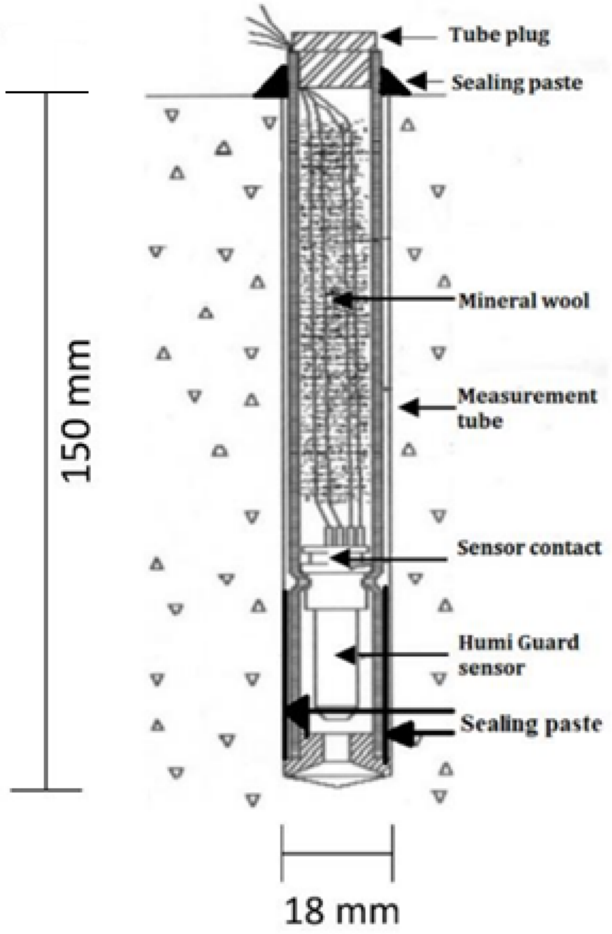
Forsøgsopsætning

Principskitse

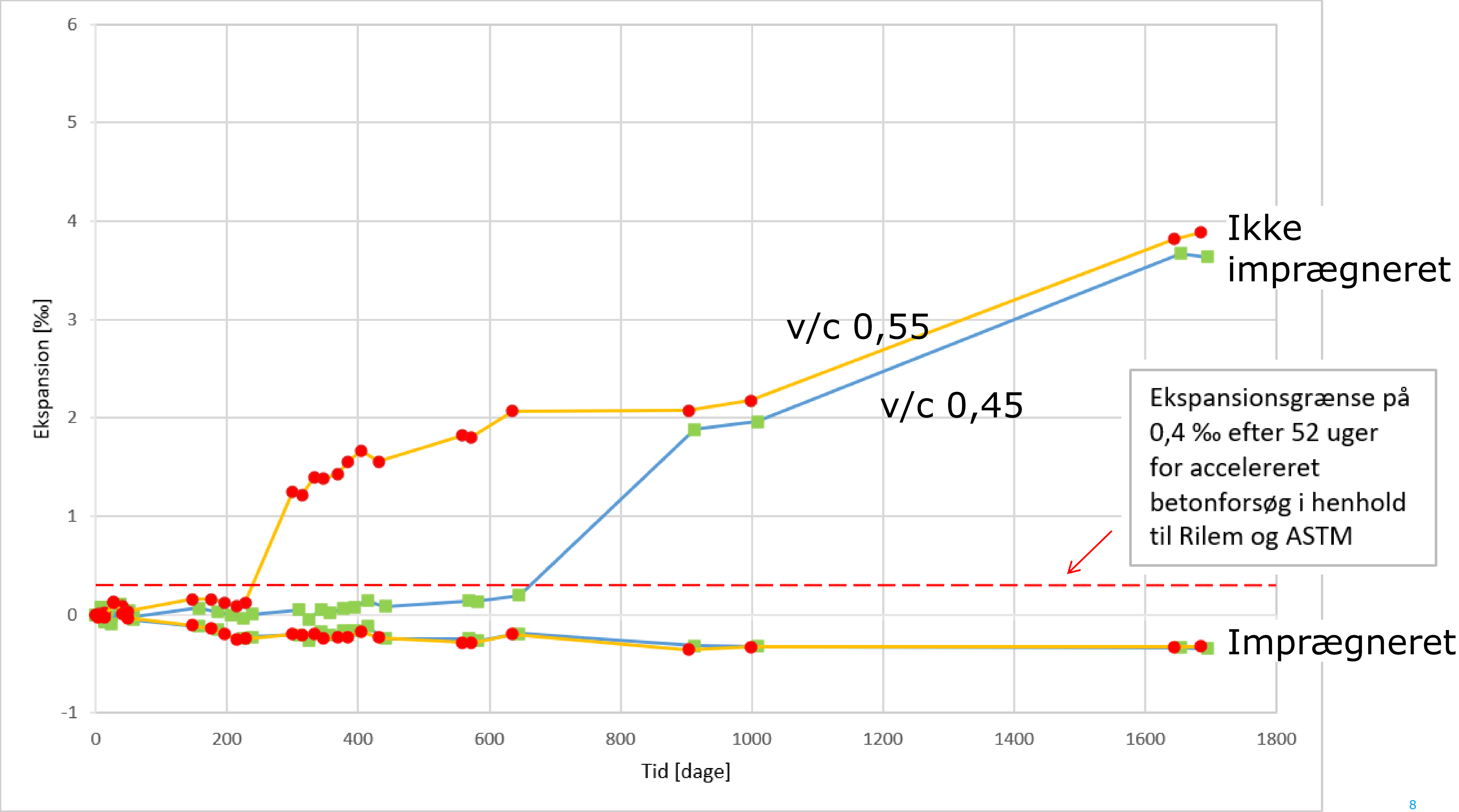


Lokation af fugtsensorer

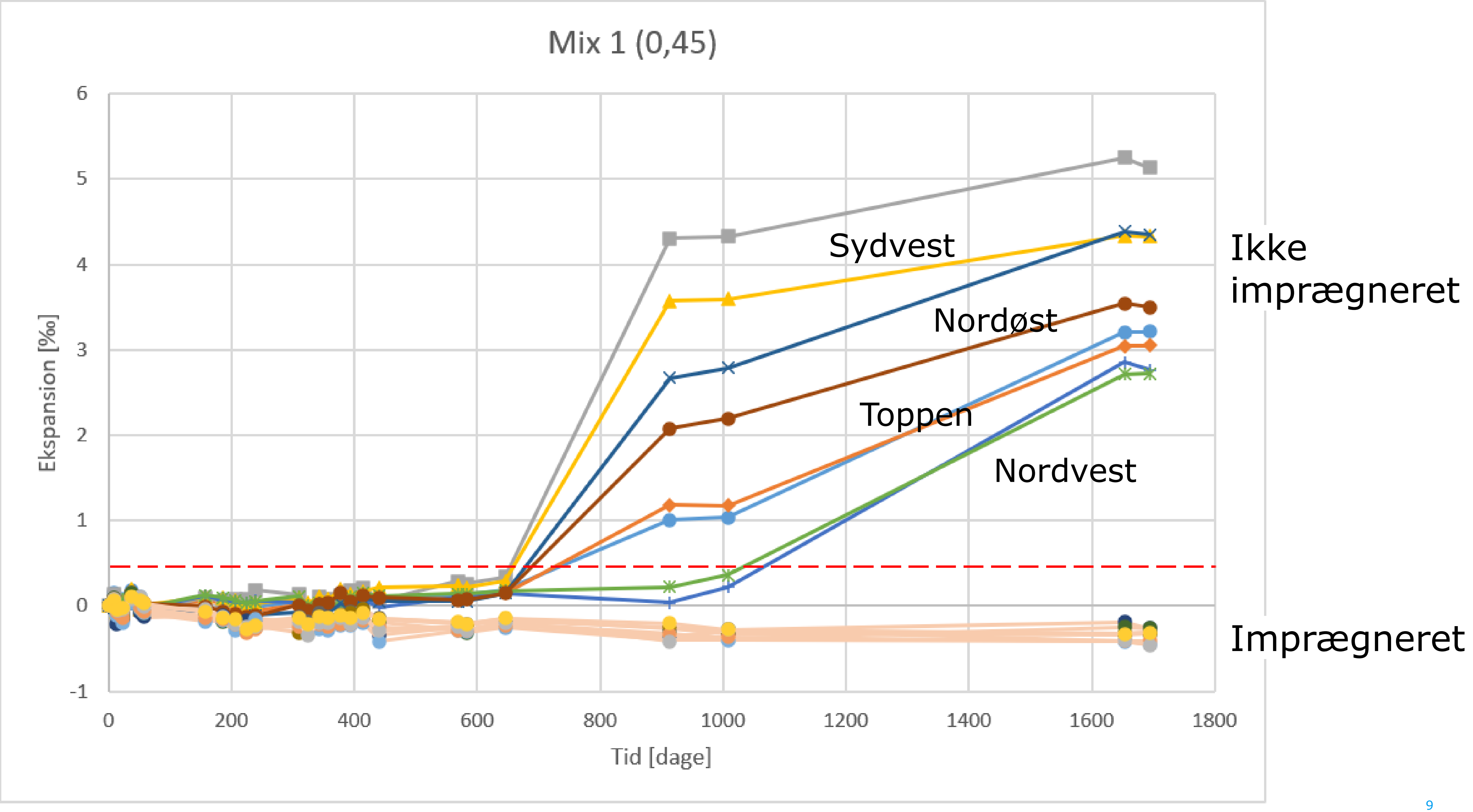
Humi Guard sensor



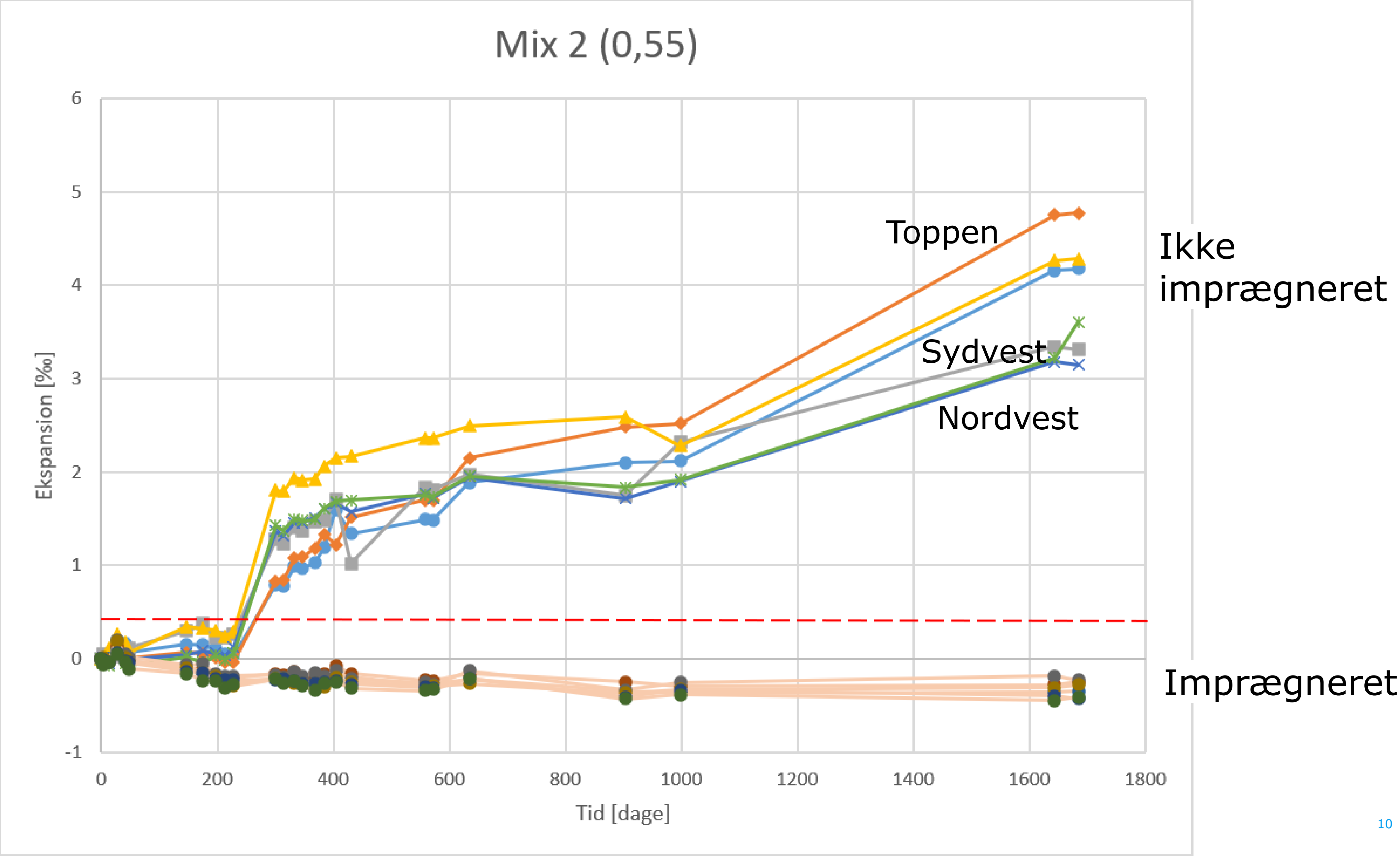
Ekspansionsmålinger af betonblokkene



Ekspansionsmålinger af Mix 1 (0,45) – alkaliindhold 5 kg/m³

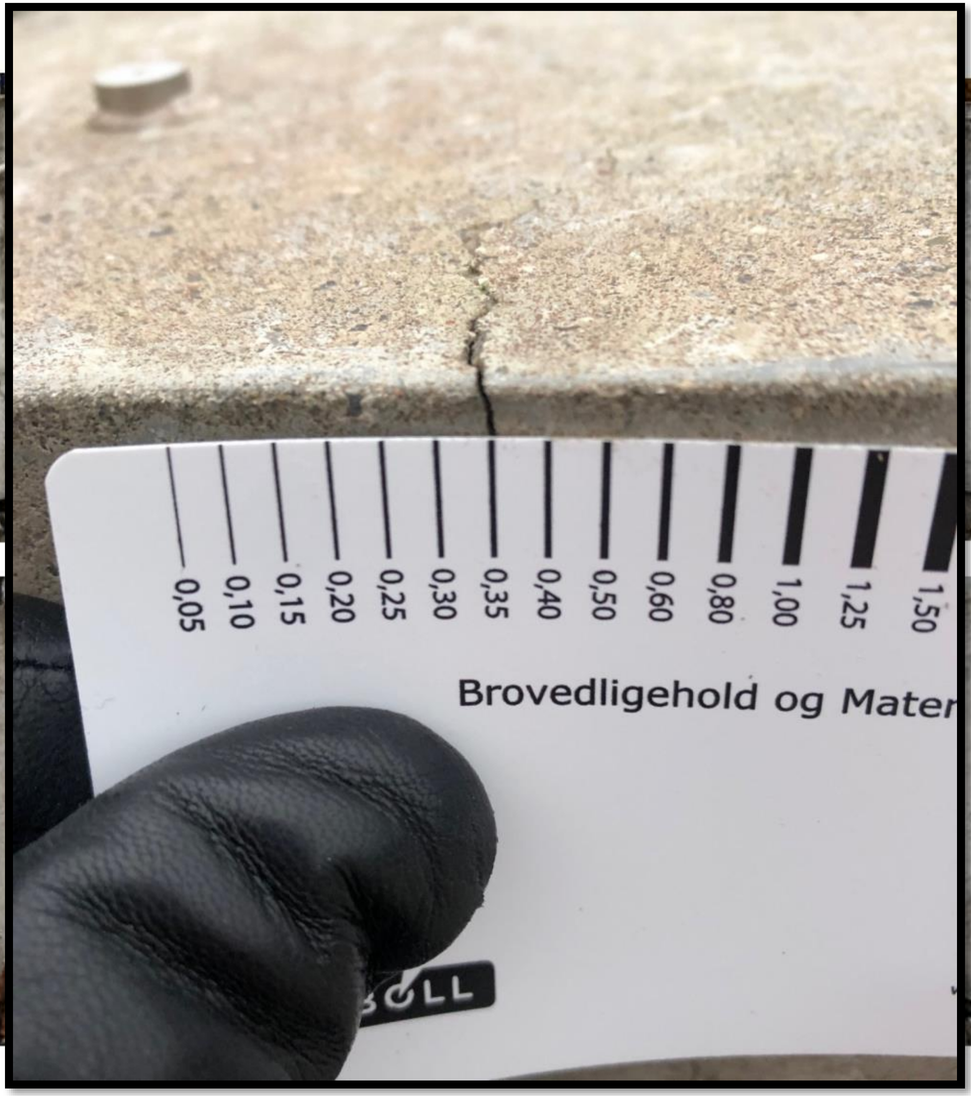


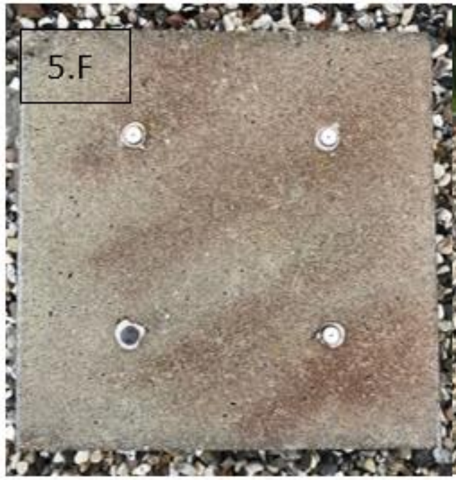
Ekspansionsmålinger af Mix 2 (0,55) – alkaliindhold 5 kg/m³



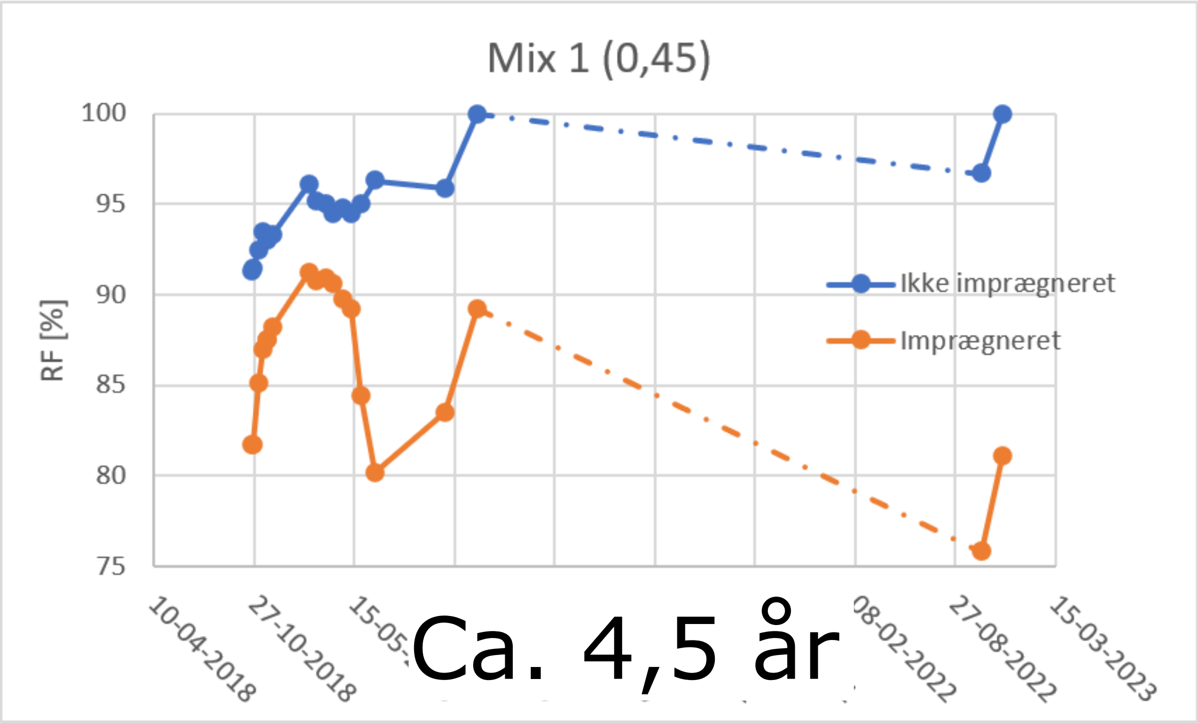
Visuel registrering af betonblokkene mix 1 (0,45)

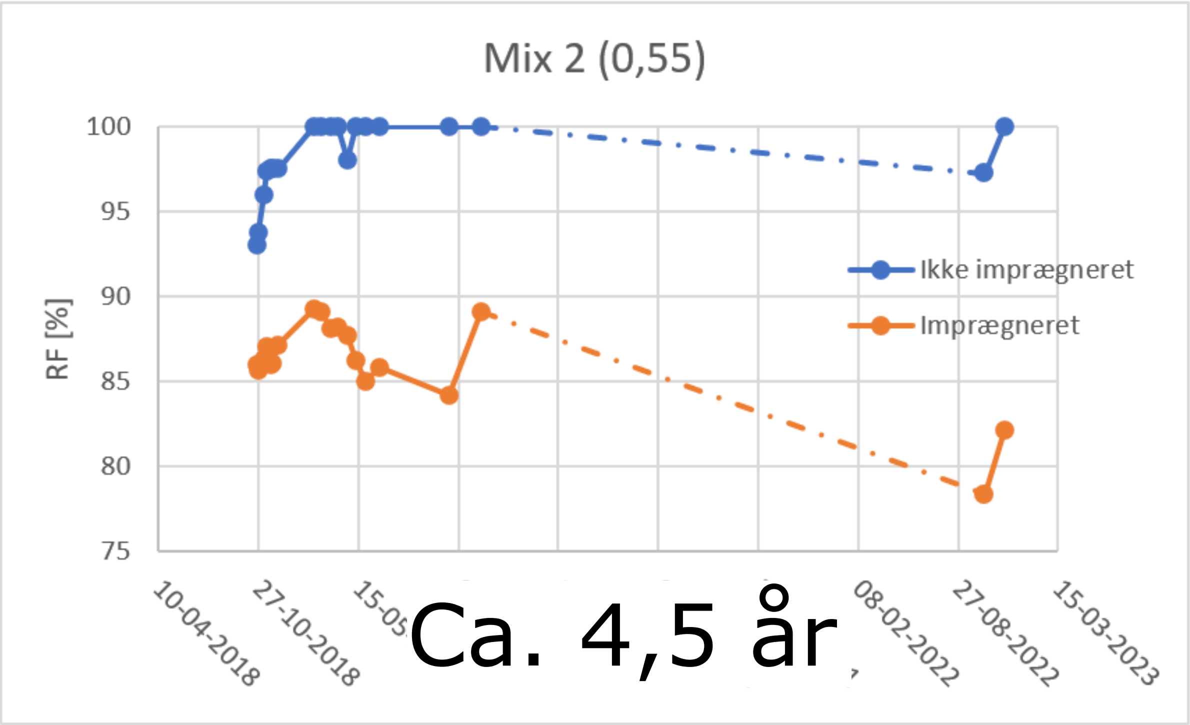
Visuel registrering af betonblokkene mix 2 (0,55)





Fugtmålinger mix 1 (0,45) og mix 2 (0,55)





Sammenfatning

- Markant forskel på ekspansion- og fugtresultaterne mellem imprægnerede og ikke imprægnerede blokke
- Ekspansion starter efter 3/4 år for ikke imprægneret blok med v/c-forhold 0,55
- Ekspansionen starter efter 2 år for ikke imprægneret blok med v/c-forhold 0,45
- De målte ekspansioner understøttes af revnedannelser ved visuel registrering (fotos)
- Tilsvarende imprægnerede emner udviser stadig ikke nogen ekspansion efter 4,5 år
- Orienteringen af prøveblokkenes sider har betydning for ekspansionernes størrelse af disse

Konklusion

- Imprægneringens effektivitet/holdbarhed synes at være > 5 år (+4,5 år).

- Den aktuelle imprægneringstype medfører tilsyneladende en netto udtørring af betonen - selv i et stærkt udsat miljø med slagregn (v/c: 0,45 og 0,55)

- Det må antages at denne effekt er endnu mere udpræget for selvudtørrende betoner (v/c < 0,40).

Fremtidigt arbejde

- Vigtigt at fortsætte undersøgelserne på DTUs eksponeringsareal – gerne de næste 20 år – dette kræver ekstern finansiering.

- Supplerende betonundersøgelser

  Varierende alkaliindhold
  Varierende v/c-forhold (0,35-0,60)
  Reaktivt tilslag (danske og udenlandske materialer)
  Nye danske cementer (Future cement og Solid cement)
  Puzzolaner (typer og indhold)
  Imprægneringens indvirkning og holdbarhed

Tak for opmærksomheden ☺

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For de interesserede er det muligt at downloade nedenstående rapporter (gratis):

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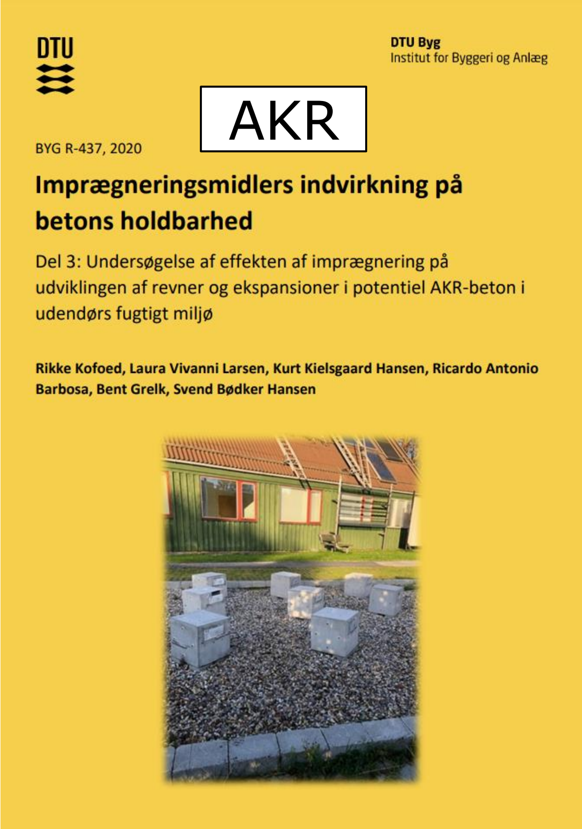

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Controlling ASR in Concrete by Surface Treatment - Field Performance Investigation

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(4) All Remove, Glostrup, DENMARK

Abstract

Several concrete structures in Denmark have been built with potentially ASR-[illegible]ctive aggregates. Most of these concrete structures have been constructed in the 60's and 70's a[illegible]cludes more than 600 large concrete bridges. Unfortunately, during the last 10 to 20 years [illegible] increa[illegible]g number of these concrete structures have become severely deteriorated due to alkali-[illegible]ica reaction [illegible]. Since it can be extremely expensive to replace these concrete structures, it is [illegible]sirable [illegible] develop and implement better economic methods to prolong the service life of these concr[illegible]. Surface treatment of concrete samples in the laboratory shows promising result[illegible] controlling the moisture content. The surface treatment can delay or even prevent the ASR f[illegible] de[illegible]oping. In th[illegible] study, it is investigated whether silane-based surface treatment can reduce [illegible] rel[illegible]umidity inside the concrete. Eight concrete cubes (0.3×0.3×0.3m³) with water/cement-ratios of 0.45 and 0.55 have been casted and exposed to outdoor climate conditions over a pe[illegible]od of nearly thr[illegible] years. Half of the concrete cubes contain ASR-reactive aggregates (po[illegible] opal[illegible] flint) a[illegible] of the concrete cubes have been impregnated with a silane-base[illegible] surface [illegible]ent. Moisture and temperature sensors (HumiGuard) measure the relative humidity and [illegible] temp[illegible] the concrete cubes during outdoor exposure (field exposure). The results of this [illegible]dy sho[illegible] that the surface treatment can significantly reduce the relative humidity inside the con[illegible]. [illegible]thermo[illegible] it is shown that the ASR expansion was delayed or even prevented by avoiding e[illegible]ernal mo[illegible]re contribution to the ASR development. The w/c-ratio has a significant influenc[illegible] the i[illegible]ation of cr[illegible]ing in the concrete cubes.

Keywords: *alkali-silica r[illegible], [illegible], field exposure, moisture sensor, silane-based surface treatment.*

1. INTRODU[illegible]TION

Service-life extension [illegible] concrete structures with potential to develop deleterious alkali-silica reaction (ASR) is a major interest for public building owners around the world. A possible extension of service-life results in significant economic savings for the society, due to reduced costs for repair works or avoiding replacement of the structure. In Denmark, the Danish Road Directorate estimated in 2008 that at least 600 larger road concrete bridges have the potential to develop ASR [1]. The 600 concrete bridges do not include municipal bridges, railway bridges or other types of construction elements, such as walls, road barriers and others. Potential means that the bridges are constructed with a critical amount of porous opaline or calcareous opaline, which is known to be very fast reactive aggregate resulting in significant cracks in the structures under the right circumstances. In Denmark, five concrete bridge structures have been demolished due to ASR [2]. Moreover, thousand meters of cantilever beams from several structures have been replaced due to the formation of severe ASR cracks. The estimated cost for replacement of ASR deteriorated edge beam is 1,500 Euros per meter [3].

Therefore, there is a great potential for the Danish Road Directorate and other building owners to implement preventive methods to reduce future economic costs for repairs and replacements of these potential ASR structures. In this context the Technical University of Denmark took the initiative to initiate a project to investigate the durability of field exposed concrete with and without surface treatment in

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Udkast

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