


RISE

ALKALI LEACHING FROM AN ASR-AFFECTED DAM

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RISE Research Institutes of Sweden
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Introduction & objectives

- Post-doc 2015-2017, Trondheim, NTNU/SINTEF
 - Part of KPN project (2014-2018)
"ASR in concrete – Reliable concept for performance testing"
Project leader: Jan Lindgård
- Post-doc: focus on the free alkali metals content in concrete




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Introduction & objectives

- Research questions:
 - What is the contribution of the constituent materials (e.g. aggregates) to the alkali metals in the solids and the pore solution?
 - How does the exposure affect the alkali content of the concrete and the spatial distribution of the alkali?
- Investigation
 - Laboratory samples: testing and comparison of methods to determine the free alkali metal content
Plusquellec et al, CCR 96 (2017)
 - Field samples: bridges & dam


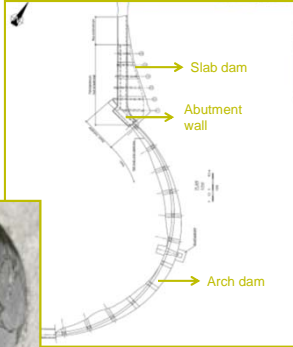





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The Votna I dam

- Situated in South Western Norway
 - Built during 1965-1967
 - Arch dam with abutment wall + slab dam
 - Affected by ASR
 - Internal humidity

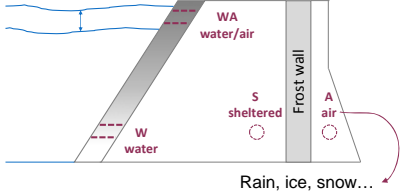
Photos: Plusquellec

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Material and methods

- Sampling of Votna I:
 - Cores taken from 4 different location → Different environmental conditions



Rain, ice, snow...






Photo: S. Å. Ekkje


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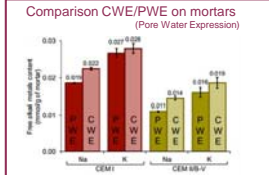
Photo: Plusquellec

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Material and methods

- CWE - Cold Water Extraction
 - Preparation (grinding)
 - Extraction (leaching + filtering)
 - Analysis of the pore solution (Pipetting for elemental analysis)
 - Calculation

Free alkali content $\text{mmol/kg} - \text{Na}_2\text{O}_{\text{eq}} \text{ kg/m}^3$
 $\text{mmol/l} =$ If the free water content is known
- CWE applied at various depth
 



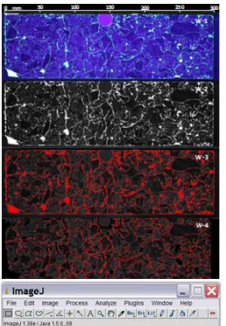
Comparison CWE/PWE on mortars (Pore Water Expression)

Plusquellec et al, Cement and Concrete Research 96 (2017)

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Material and methods

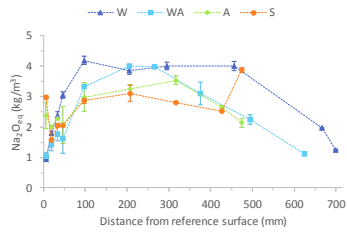
- Crack density
 - Fluorescence-impregnated plane-polished sections
 - UV light
 - "green image" after RGB separation
 - Thresholding
 - Removing of air voids + correction of cracks width
 - Crack density measured with ImageJ in function of the depth

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Results

Alkali metal profiles



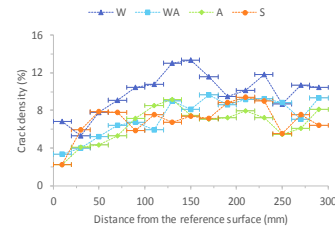
- **W & WA:** Similar leaching profiles. Leaching affects the concrete in the first 100 mm.
- **A:** Leaching is less pronounced
- **S:** Leaching and indication of wick action



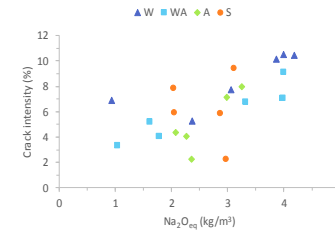
Aggregates release alkali metals during CWE
→ results must be corrected

Results

Crack density



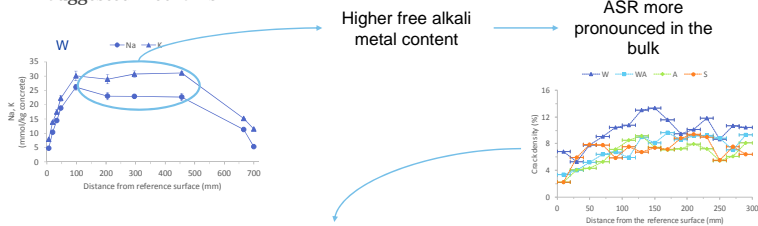
More alkalis metals in the bulk → higher cracks density



Crack density increases with free $\text{Na}_2\text{O}_{\text{eq}}$ (except location S)

Results

Suggested mechanism



Higher free alkali metal content

ASR more pronounced in the bulk

Indication of an expanding bulk and an outer skin which expands less

Tension in the surface

Map cracking



Conclusion

- Measurement of the free alkali metal profiles at different locations/environmental conditions
 - Difference in leaching according to the location
 - Leaching can also be associated with wick action
- The free alkali metal content corresponds with the crack density
- The map cracking typical for ASR-affected structures can be explained by a "skin effect": the bulk expand more than the surface, leading to tension.
- More details in:

"Determining the free alkali metal content in concrete – case study of an ASR-affected dam"
Plusquellec G., Geiker M.R., Lindgård J., De Weerd K.
Accepted for publication in CCR.



THANK YOU!

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