DANISH TECHNOLOGICAL INSTITUTE

Expert Centre for Infrastructure Materials

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Expert Centre for Infrastructure Materials

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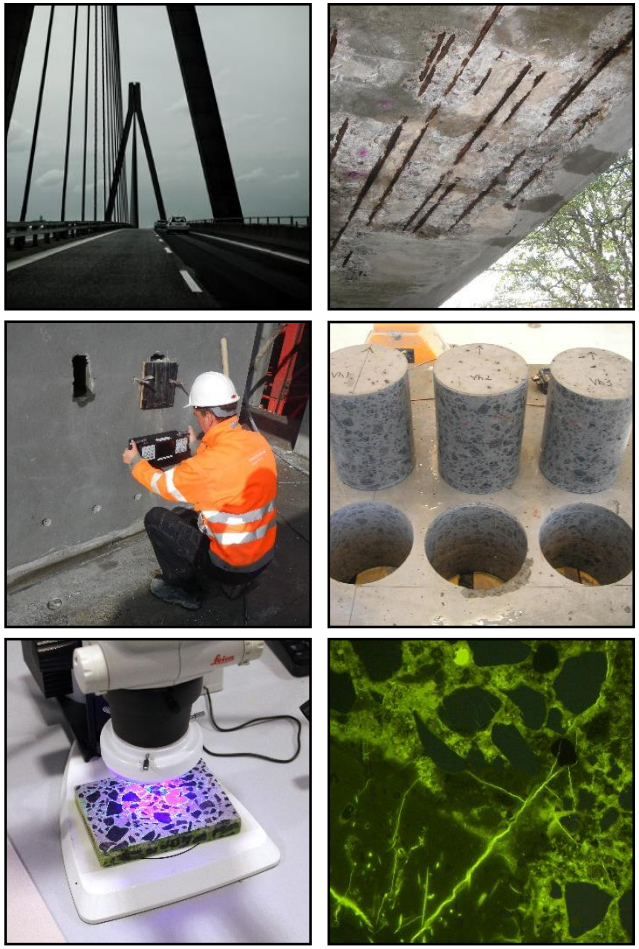
- Research on materials for infrastructure constructions, e.g. concrete and alternative new materials.
- Established in 2010.
- Close collaboration between:
  - Danish Technological Institute
  - Technical University of Denmark
- Financed by: Danish Agency for Science, Technology and Innovation (Ministry of Higher Education and Science).



Research topics

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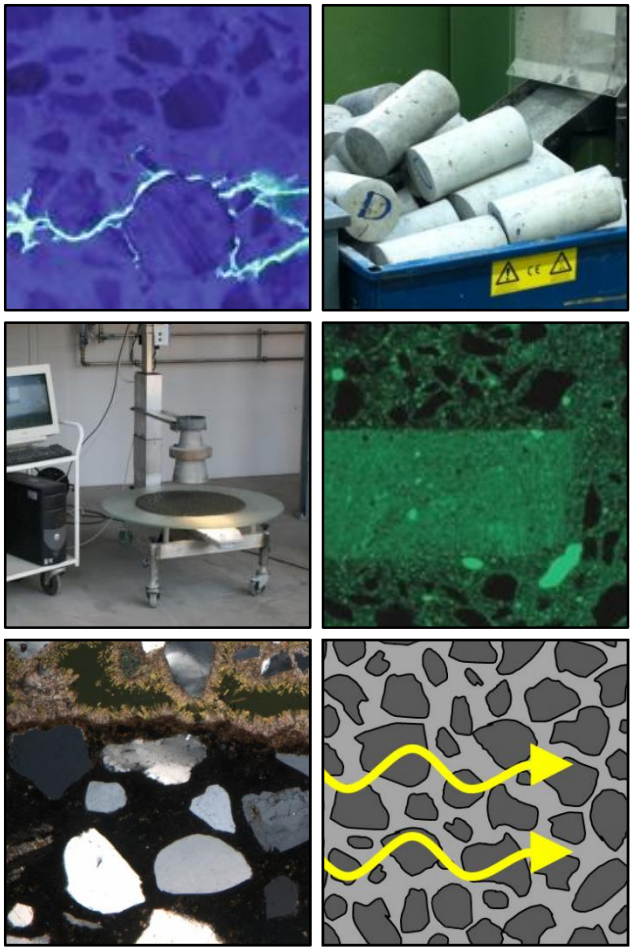
- Concrete durability
- Service life modelling
- Life cycle assessments for concrete structures
- Measuring techniques for condition assessment of structures
- Critical construction details and execution errors
- New and alternative materials for infrastructure constructions



Reference group

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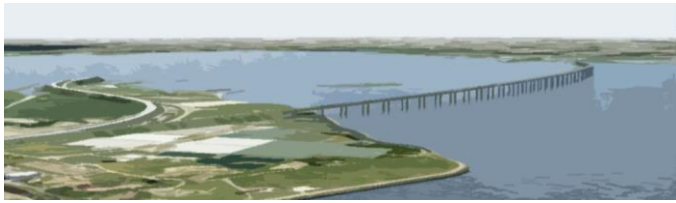
- Alectia
- Arkil
- A/S Storebælt
- A/S Øresund
- Banedanmark
- Broconsult
- C.F. Møller
- Colas
- Convi
- COWI
- CRH Concrete A/S
- DTU
- Dansk Byggeri, Belægningsgruppen
- Dansk Byggeri, Betonelementforeningen
- Dansk Byggeri, Danske Anlægsentreprenører
- Dansk Byggeri, Fabriksbetongruppen
- Dansk Konstruktions- og Betoninstitut A/S
- DONG Energy
- EKJ Rådgivende Ingeniører Emcon
- Emineral A/S
- Femern A/S
- Fiberline Composites
- Grontmij A/S
- Haucon A/S
- Herning Kommune
- Hi-Con A/S
- IBF
- Københavns Erhvervsakademi
- Lemminkäinen A/S
- Metroselskabet I/S
- MT Højgaard A/S
- Munck Asfalt A/S
- NCC Roads A/S
- NIRAS A/S
- Pankas
- Per Aarsleff A/S
- Rambøll
- TOTAL Danmark A/S
- Unicon A/S
- Vejdirektoratet
- Via University College
- Aalborg Portland A/S
- Aalborg Universitet



Why are the activities of the Expert Centre relevant?

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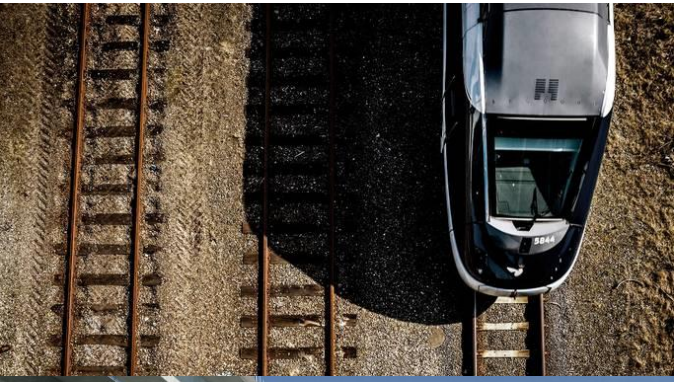

- Currently many large on-going and planned infrastructure projects in Denmark, e.g.:
  - Expansion of Copenhagen Metro: City Circle Line
  - Fehmarn Fixed Link between Denmark and Germany
  - Upgrading and extension and of the rail way infrastructure
  - A number of large new coast bridges
  - Extension of the highway infrastructure

- Growing need for development of new technologies to supply the construction sector

Development of concrete properties

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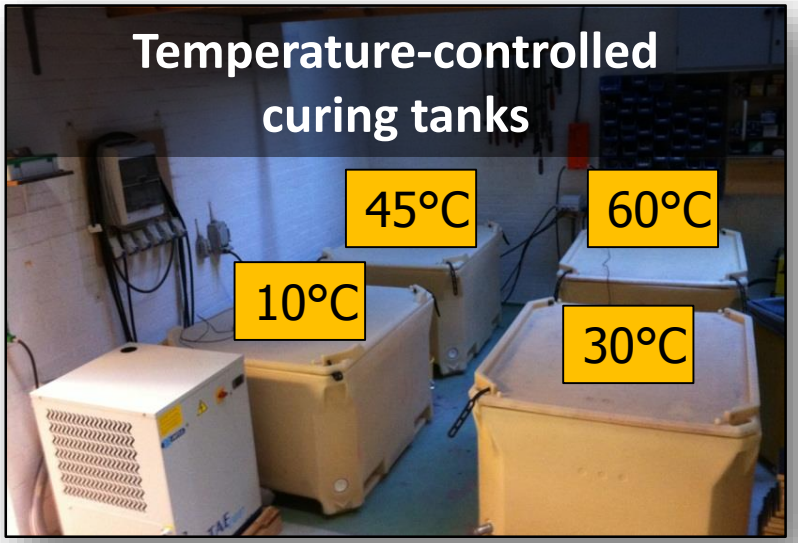

Development of concrete properties

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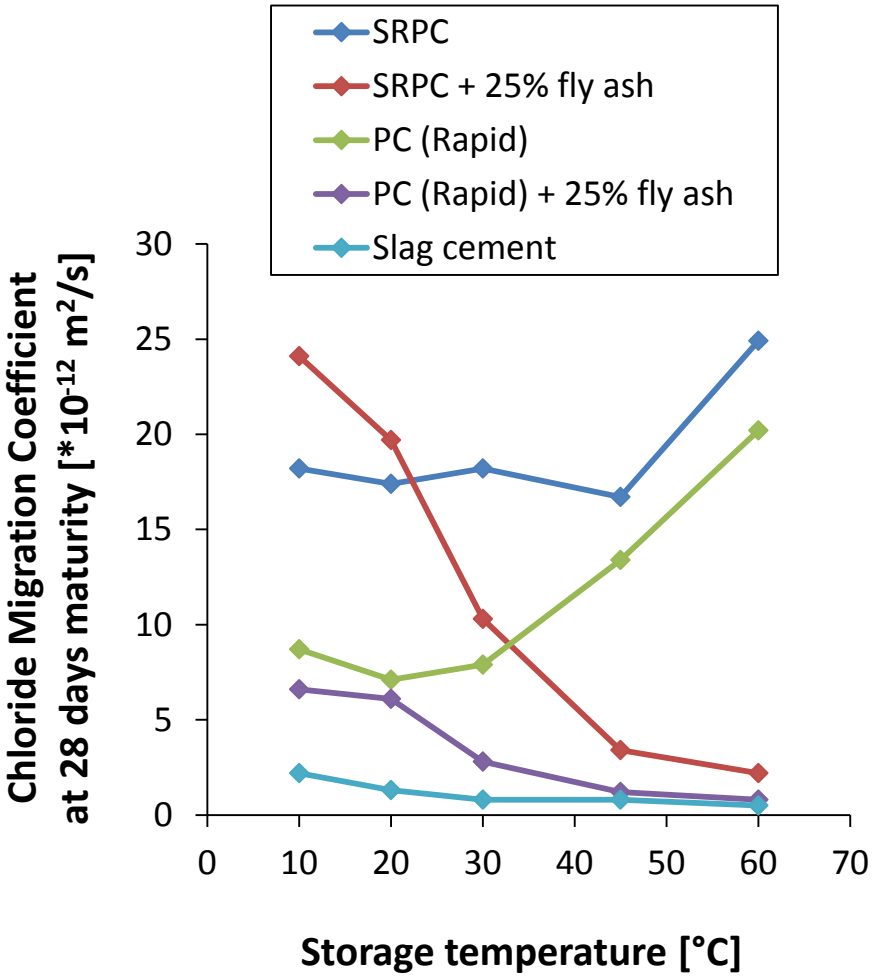

Example of results

- The resistance to chloride ingress is greatly improved for fly ash concretes by high-temperature initial curing.
- Slag cement concretes show very good resistance to chloride ingress at all studied curing temperatures.

Critical structure details

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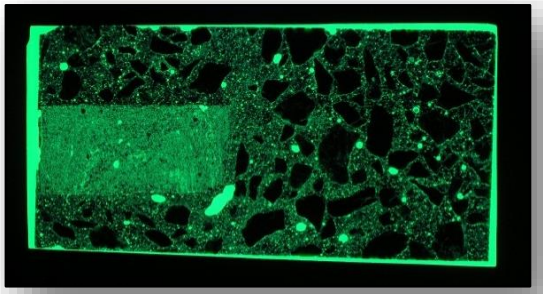
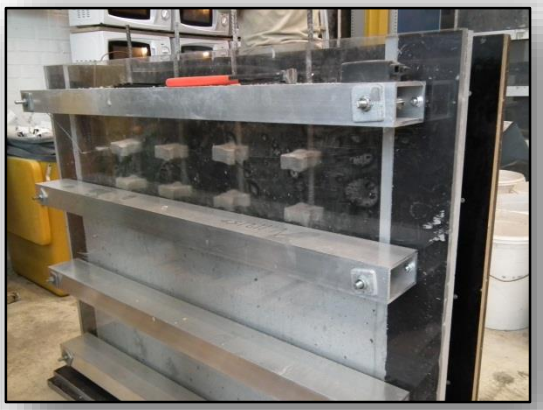
- The influence of critical structure details on the durability of concrete has been investigated.
- Investigations of the influence of poker vibrator track, cold and warm casting joints, reinforcement spacers, and water dosage in self-compacting concrete.





Critical structure details

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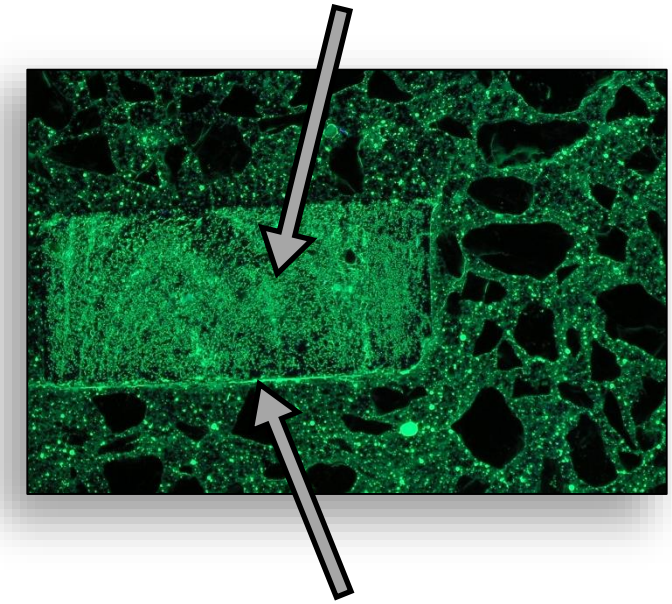
CAST-IN REINFORCEMENT SPACER OF MORTAR



INCREASED POROSITY (BRIGHT GREEN) IS OBSERVED BELOW THE SPACER

Example of results

- It is difficult - if not impossible – to avoid an increased porosity in the region immediately below cast-in reinforcement spacers.
- We have observed a tendency for dry spacers to display a lower porosity below the spacer as compared to water-saturated surface-dried spacers.
- The increased porosity observed below the spacers results in a reduced resistance against chloride ingress.

Fehmarn Belt Exposure Site

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Source: http://one-europe.info/infographics/fehmarn-belt

CONCRETE BLOCKS EXPOSED AT RØDBYHAVN HARBOUR, DENMARK

Long-term durability

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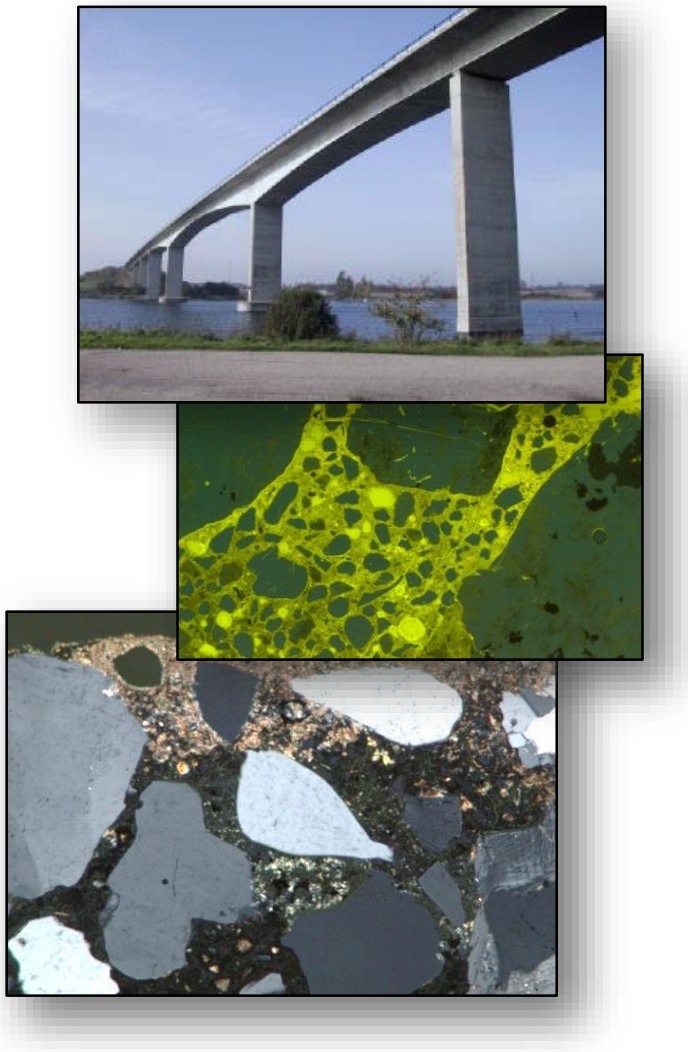
- Long-term durability of concrete constructions exposed to seawater.
- Investigations of concrete from "old" Danish bridges by microscopic methods and measuring of chloride ingress profiles.
- Results have used to develop of a modelling tool to predict the remaining service life of existing concrete structures in chloride-rich environments.



Service life design for concrete constructions

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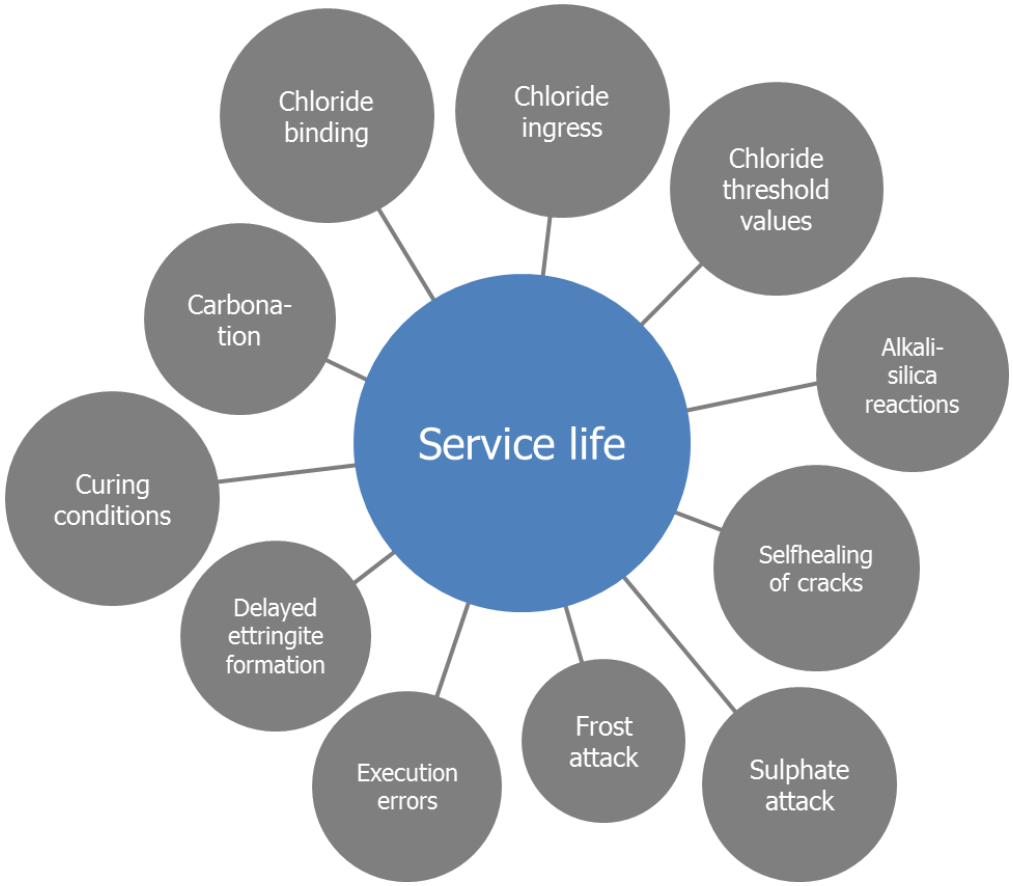
- Concept for service life design for concrete constructions based on 'plug and play' approach.
- A series of modules covering different areas having a potentially important influence on the service life.



Chloride threshold values

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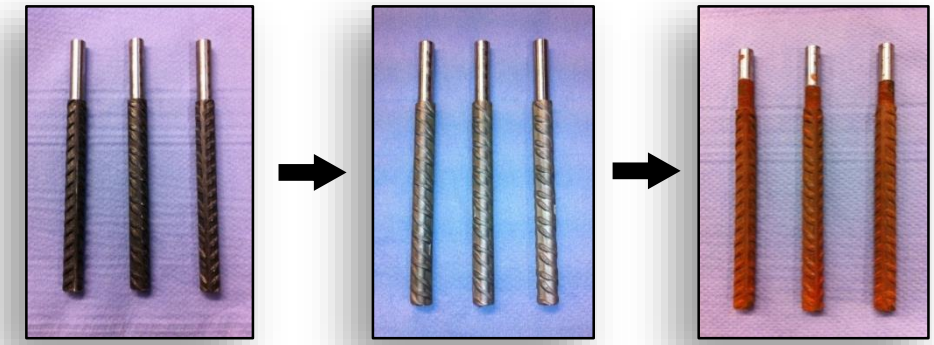
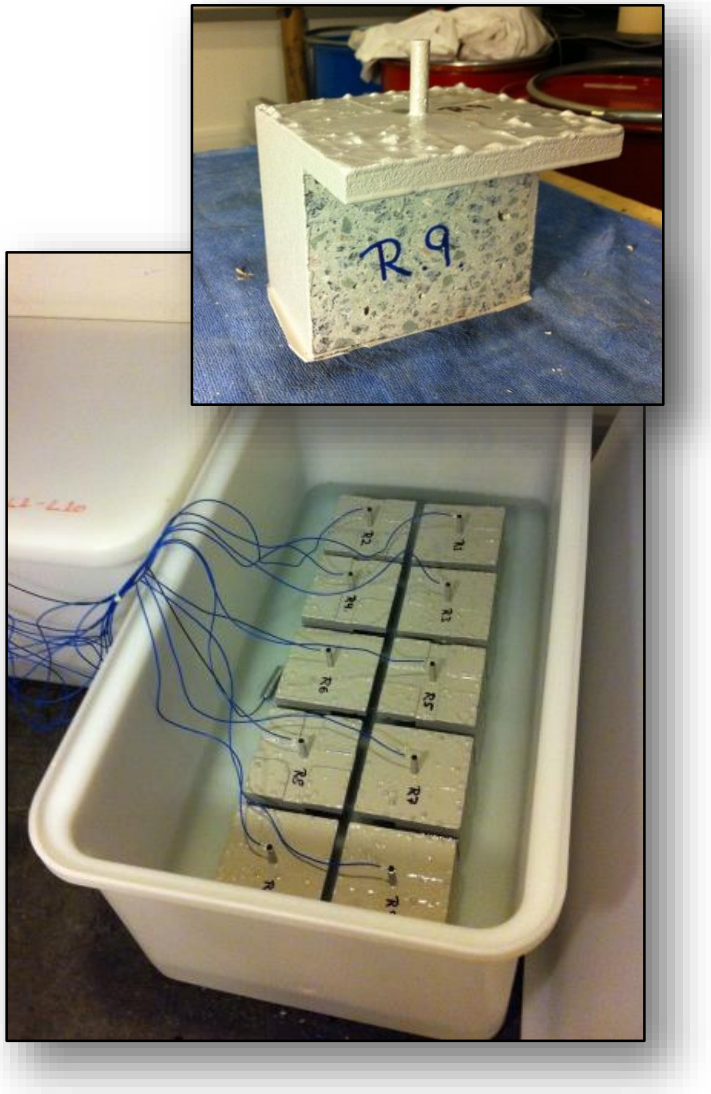
- Participation in RILEM group working on the development of a new and commonly accepted test method for determination of threshold values for chloride-induced reinforcement corrosion in concrete.
- The test method is based on open circuit measurements on pre-rusted rebars in concrete specimens exposed to a chloride solution.



As-received *Cleaned* *Pre-rusted*



Chloride binding in concrete

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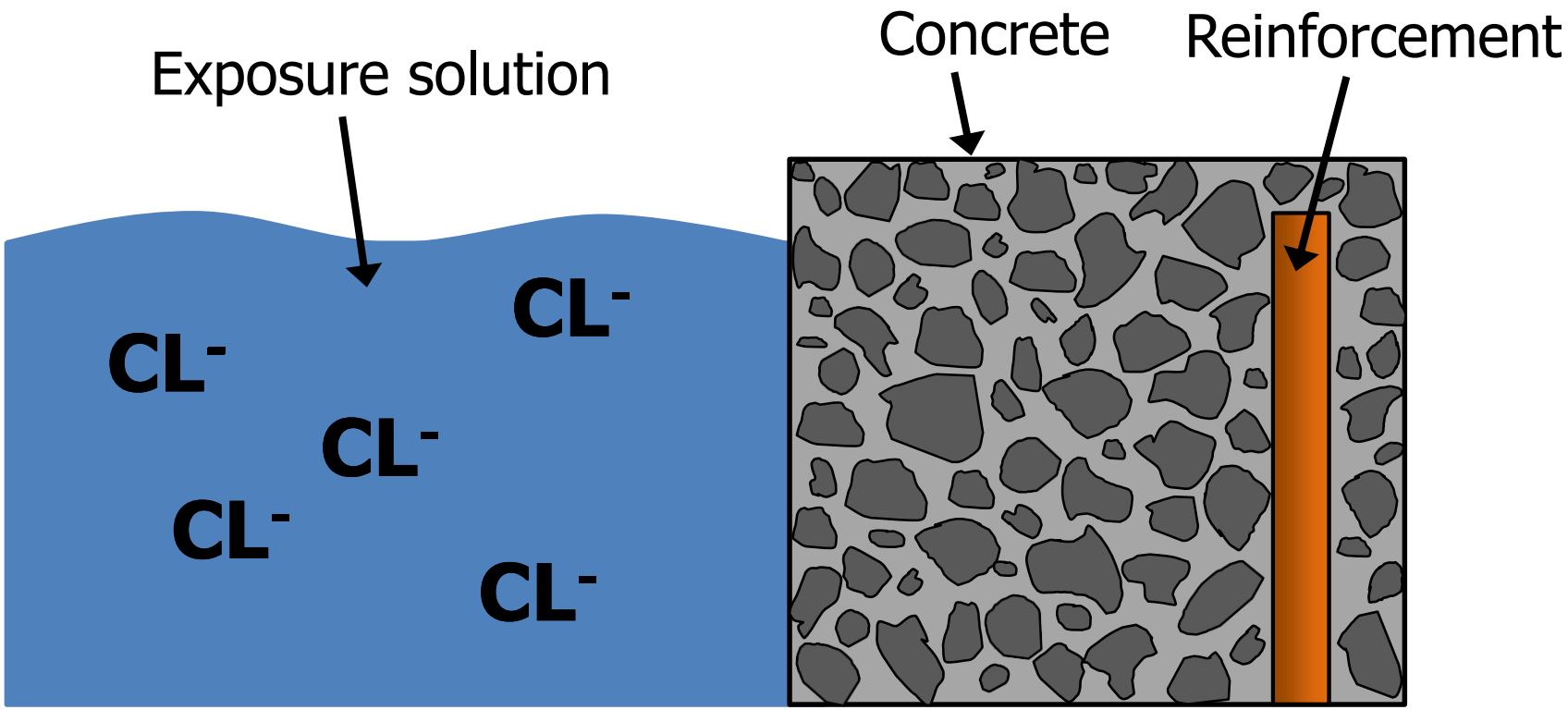

Chloride binding:

- Partial fixation of chloride ions by the hydrate phases
- Chloride ions are removed from the pore solution

Tool for prediction of chloride binding

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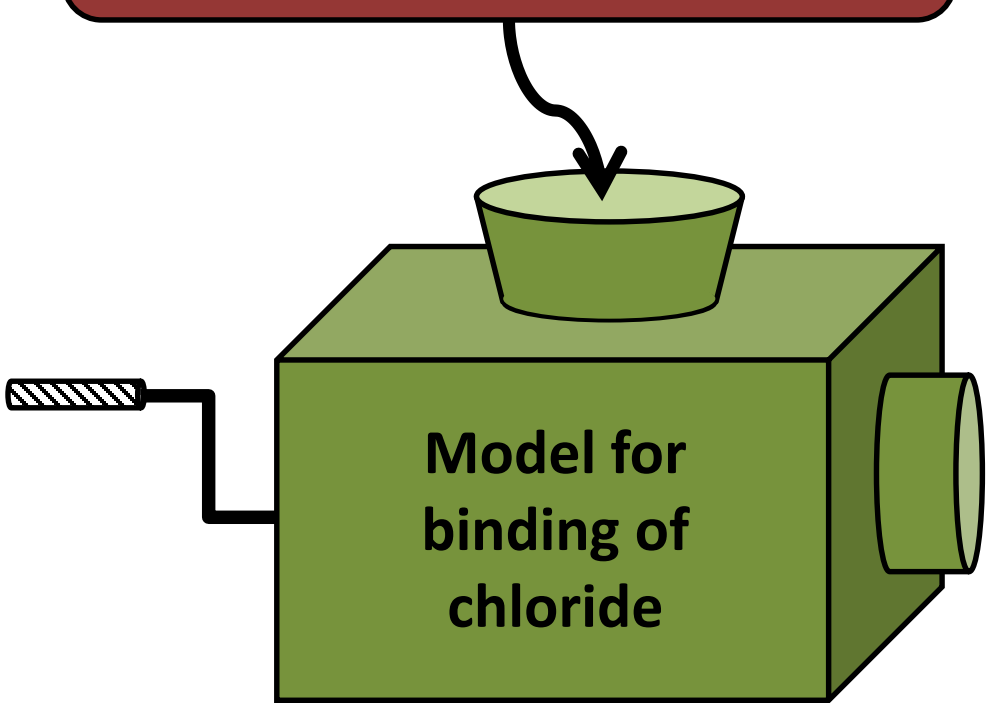
Input

- Chemical composition of system



Output

- Quantification of chloride binding.
- Chemical composition of pore solution: $[Cl^-]$, $[Na^+]$, $[OH^-]$, $[Ca^{2+}]$.
- Phase assemblage of hydrated system.

Prediction of [Cl-]/[OH-] ratios

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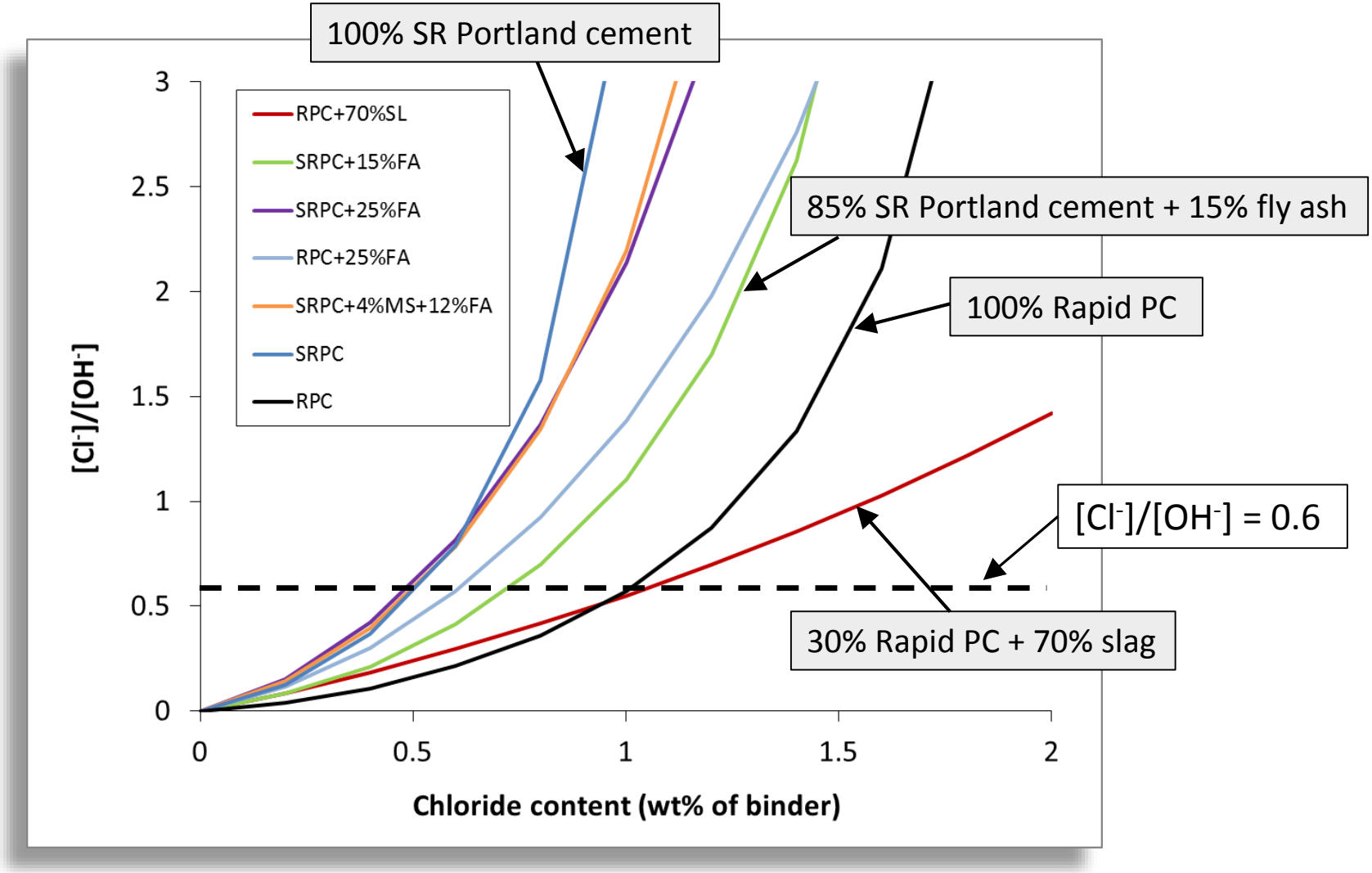

New model for chloride ingress in concrete

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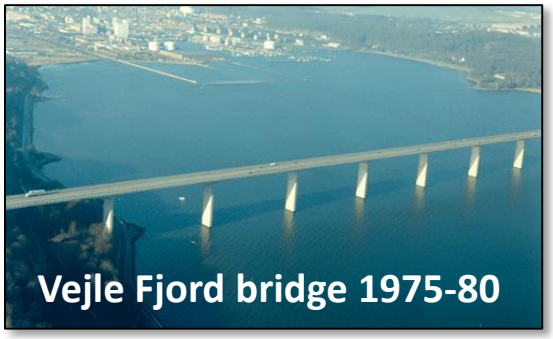
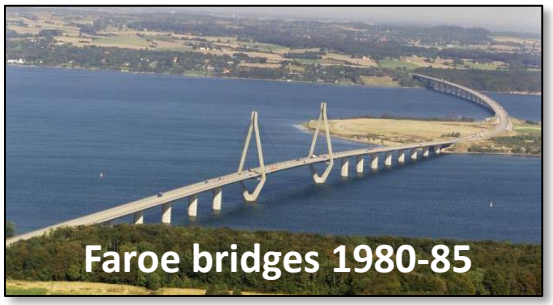
- Results from marine concrete structures:
  - Chloride diffusion coefficients becomes more or less constant after 5 to 10 years.

- Proposed new model for chloride ingress in concrete:
  - More simple approach without the use of an ageing factor.
  - The ingress is modelled by a simple linear relationship between the penetration depth and the square root of the exposure time.
  - Can be utilized to predict the service life of marine concrete structures. Perhaps with better precision.





Mock-up of concrete bridge deck

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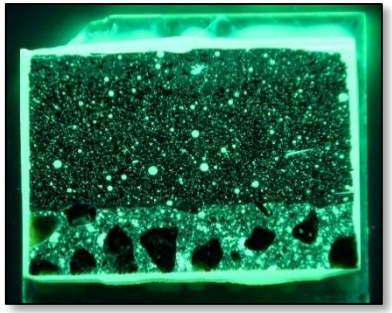
- Fabricated without traditional bitumen waterproofing.
- Ultra-high performance fibre reinforced self-compacting concrete used as alternative waterproofing.



Mock-up for Verification of Temperatures in Large Concrete Structures

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- Insulated concrete mock-up with cast-in heating wires and cooling pipes.

- Can be utilized to test the implication of:
  - Type of cooling pipes (steel, plastic)
  - Speed/temperature of cooling water
  - Heating wires and heating mats
  - Insulation materials

Visual scenery for tunnels

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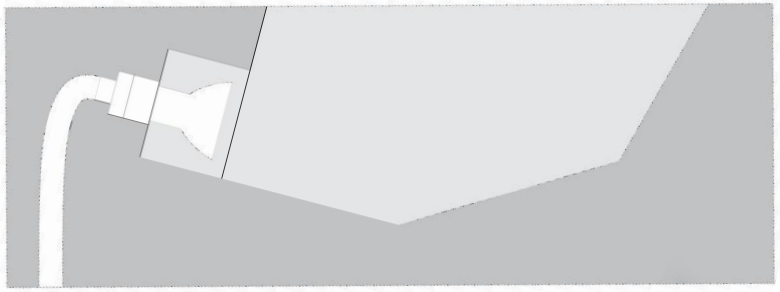
The concept

Prototype



Guideline for condition assessment of concrete structures

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- Available as:
  - Printed publication
  - App for smartphones and tablets
  - Online version (issuu.com)

New materials for infrastructure constructions

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- *State of the art* report about the potential use of alternative new materials for infrastructure constructions.

- Examples of materials:
  - Carbon fiber-reinforced concrete
  - Glass fiber-reinforced polymer composites

Website: www.expertcentre.dk

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- Collection of data from:
  - The Expert Centre's own activities.
  - Previously completed research and demonstration projects.
  - E.g. test results from the marine Fehmarn Belt Exposure Site at Rødbyhavn, Denmark.