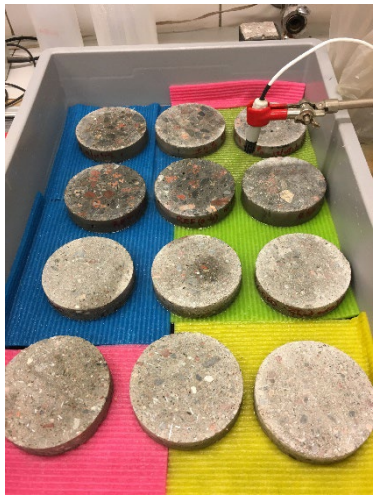
Hydrophobic Concrete



Patrick Rogers, 2023

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Background

- Concrete , and extensively the cement paste, is a region of mass transfer
- External ions , e.g. chlorides (Cl^-), sulphates (SO_4^{2-}), CO_2 in gaseous or fluid (HCO_3^-) can enter the matrix
- External application of ”silanes” is a known technique on demoulded concrete surfaces
- Bulk application in concrete with conceptual advantages

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Main objectives

- Design , mix and measure applicable characteriscs that would lead to increased technical service life of exposed concrete

  - To include a screening phase
  - To include a long term testing site
  - To include fresh and hardened properties

  - To write a licentiate thesis
  - Disseminate knowledge via conferences and or journals

Methods employed in project

- Screening on mortar specimens (w/c = 0.50)
- Compressive strength development over 3 years
- Water absorption testing on small and large specimens (w/c = 0.40,0.45 and 0.50)
- Freeze thaw testing on w/c = 0.40 concretes
- Iso thermal calorimetry
- Three month Cl^- diffusion tests in 3% weight NaCl solution 20 °C
- ”Eight years” seasonally accelerated capillary absorption testing
- Establishment of a field station on road 271 in Stockholm

Results

- Four hydrophobic agents chosen for evaluation based on:
  - TAGs (“vegetable oil”)
  - N-octyltriethoxysilane (“silanes”)
- Hindered but increasing compressive strength development with bulk hydrophobic additives even at 1% addition (cement weight)
- Increasing the addition from 1-3% (based on cement weight) decreased water absorption , but not linear. Upto 93% reduction based on W_{w24}
- Freeze thaw results are the main issue , even with a type of air entrainer added, “silanes” performed worse than TAGs

Results

- The fresh properties (slump) not affected, except in short alko component silanes (-methoxysilane)
- Only thermal difference observed (20 & 50 °C) I first 20 hours was in highly processed TAG (rapeseed oil), 4-7% increase in liberated heat measured
- Cl- diffusion reduced with inclusion of TAGs , but only effective at higher addition rates and is w/c intradependant (ca 50% reduction in diffusion coefficient)
- Additives (“silane” or “vegetable oils” effective in reducing the capillary absorption in cyclical wet dry seasonal testing
- Field station specimens four and five years old as of February 2023

Conclusions

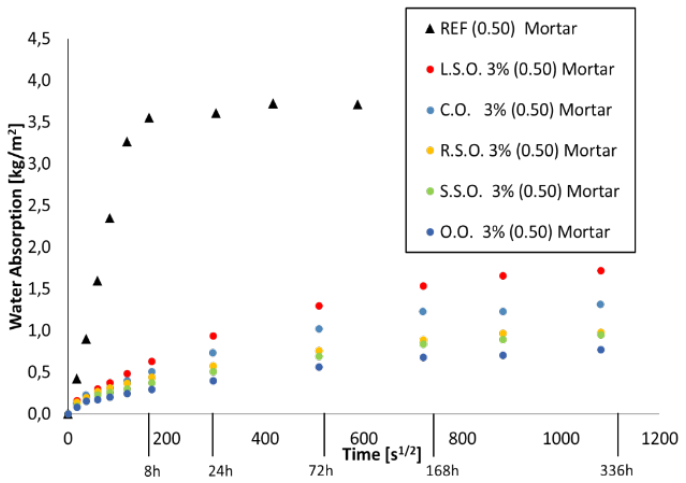
- Fresh properties are not affected with the inclusion of unprocessed TAGs or ethoxysilane based hydrophobic additives.
- Reducton of capillary suction and diffusion in the cement paste are important to increase resistance to mass transfer of detrimental ions

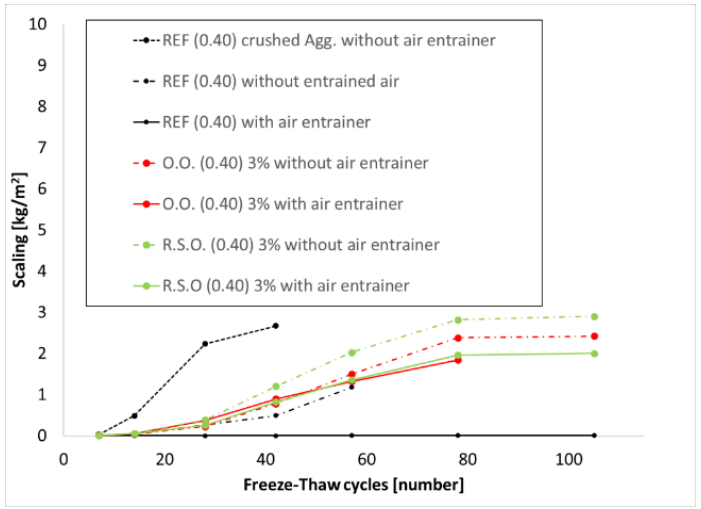
- TAGs are more effective at reducing diffusion rate of chlorides than ”silanes” but need to be adjusted to w/c of cement paste.

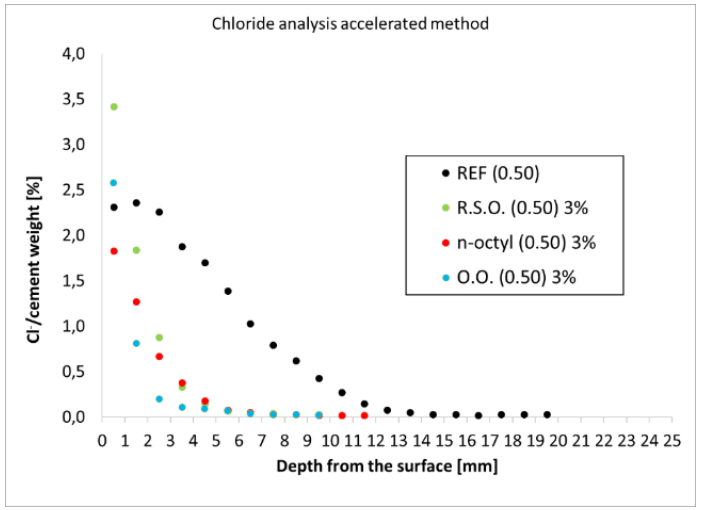
- Freeze thaw resistance (or lack of) is the main issue with these additives, more knowledge on the ”altered” cement paste structure/ air pore system is required to understand and develop this concept

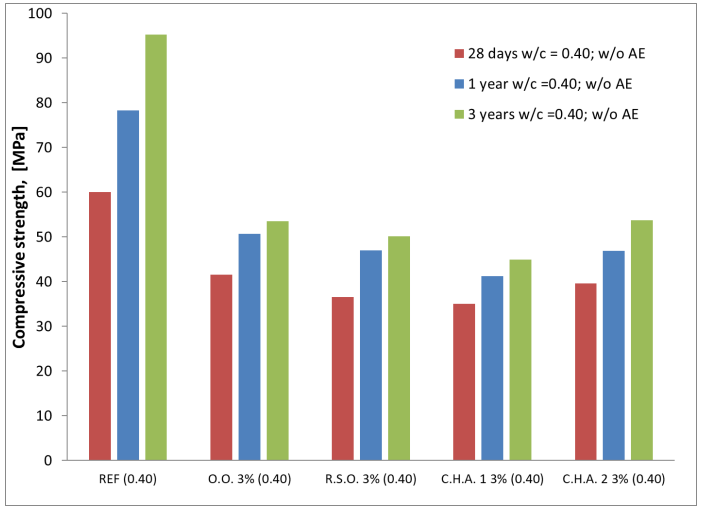
- Compressive strength is reduced even with low inclusion rates (1% = ca 4.3 kg/m^3)

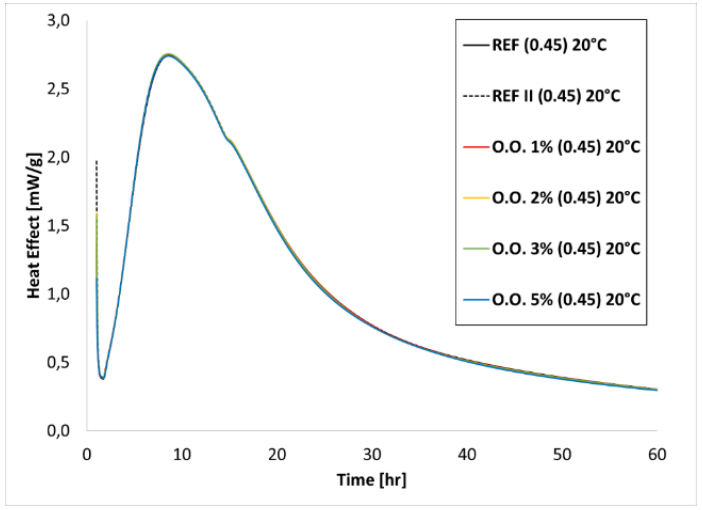
Examples from testing (not exhaustive)











R.S.O = rapeseed oil
O.O. = olive oil (extra virgin)
C.O = corn oil
L.S.O = linseed oil
S.S.O.= sesame seed oil
C.H.A. = commercial hydrophobic agent
N-octyl = n-octylethoxysilane

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