

A photograph of a concrete pavement joint showing significant deterioration and cracking. The joint is a vertical line running down the center of the frame, with a horizontal joint intersecting it near the bottom. The concrete surface is light gray and shows signs of wear, including small pits and discoloration. The background shows a grassy area and a white pole.

Abbreviated Update on Salt – Concrete Interaction as it Relates to Premature Pavement Joint Deterioration

**Robert Spragg, Wenting Li, Javier Castro,
Mohammad Pour-Ghaz, Tommy Nantung
Jason Weiss, Purdue, April 26th, 2011**



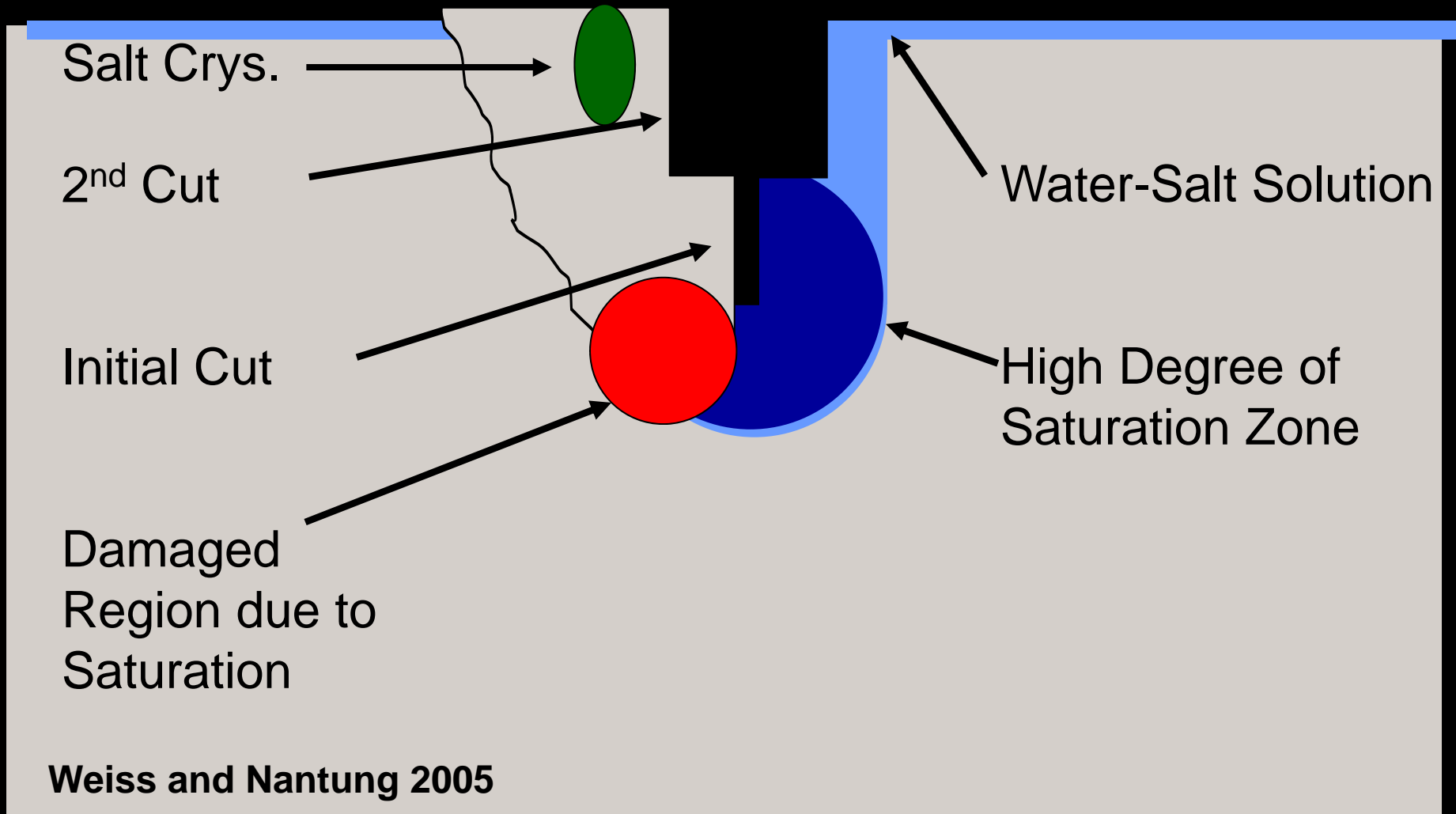
Interaction of Many Topics Several Projects Link Together



- Sawcutting, Timing and Damage
- Saturation and Freeze-Thaw
- Conceptual Model for Damage
- Saturation in Joints (Filling and Absorption)
- Absorption vs Degree of Saturation
- Viscosity and Surface Tension
- Relative Humidity Drying and Wetting
- The Role of Artificial Drying
- The Role of Sealants
- Toward a Computer Model That Can Be Used

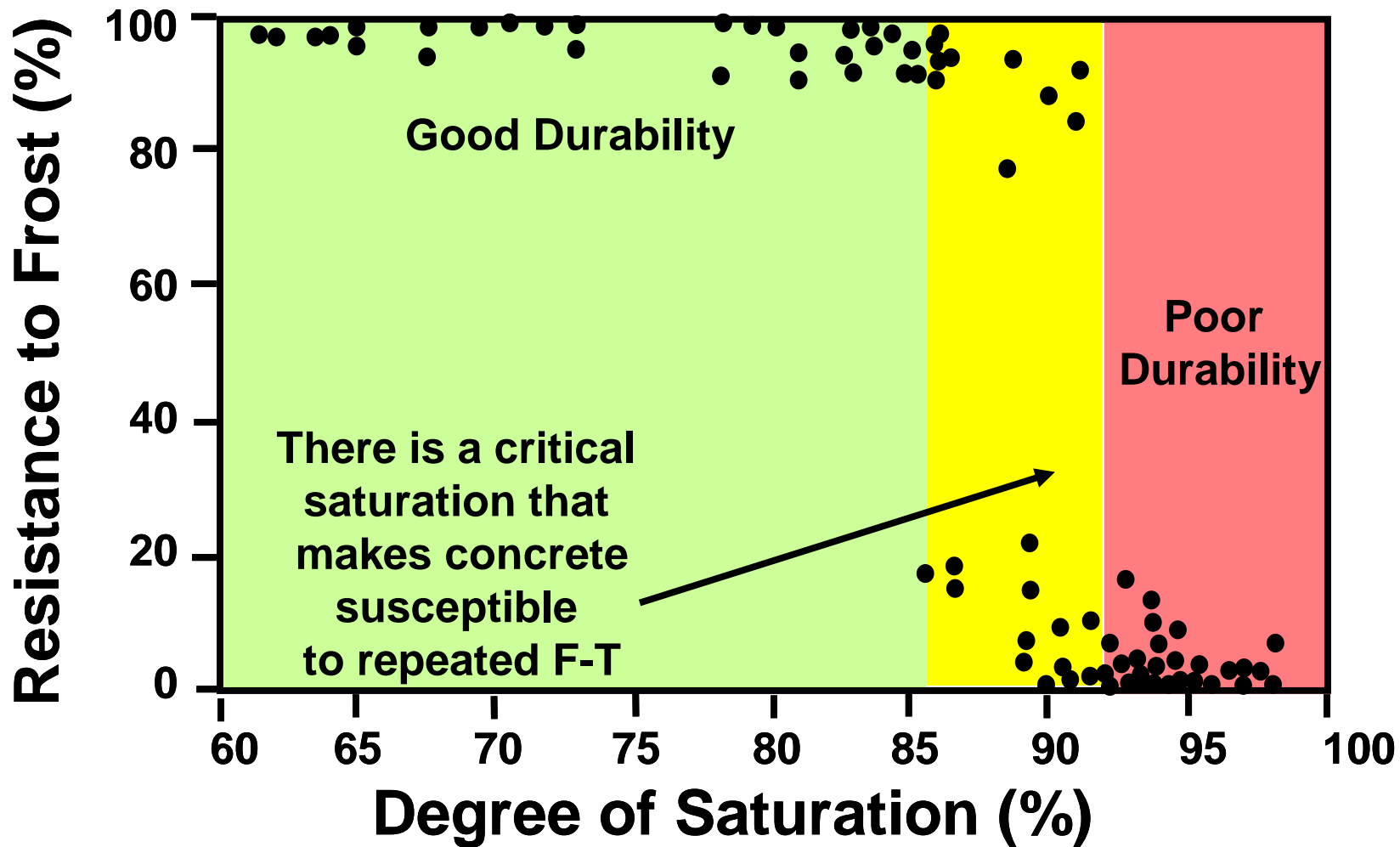


Saturation in the Joint FT and Crystallization





Saturation and Freeze-Thaw Damage



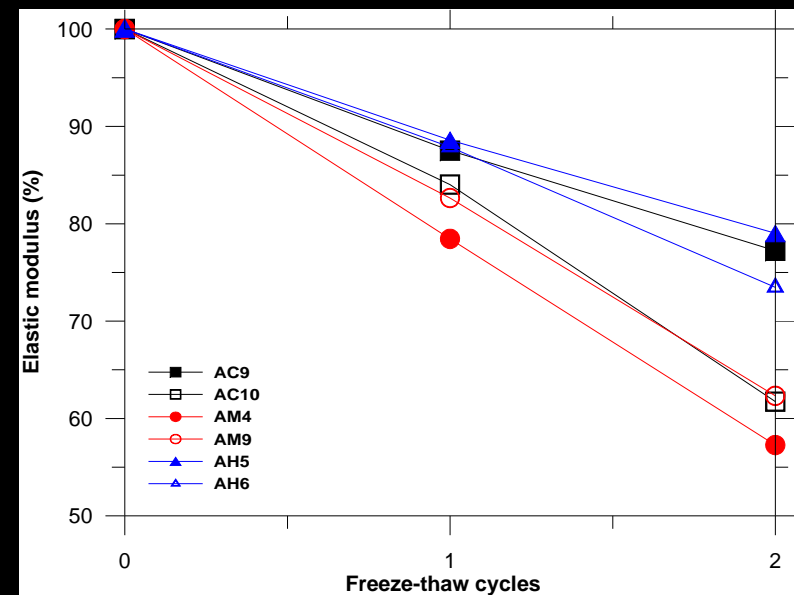
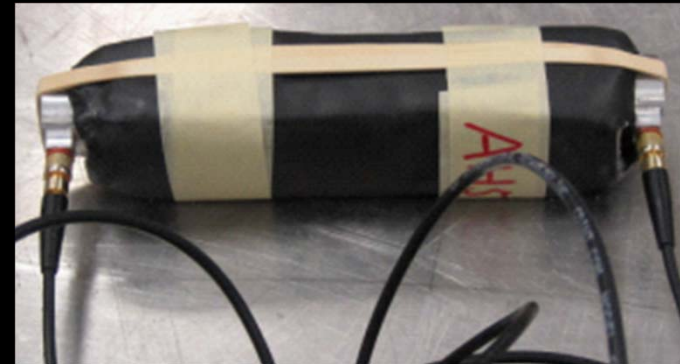
After CEB 1957



Experimental Procedures

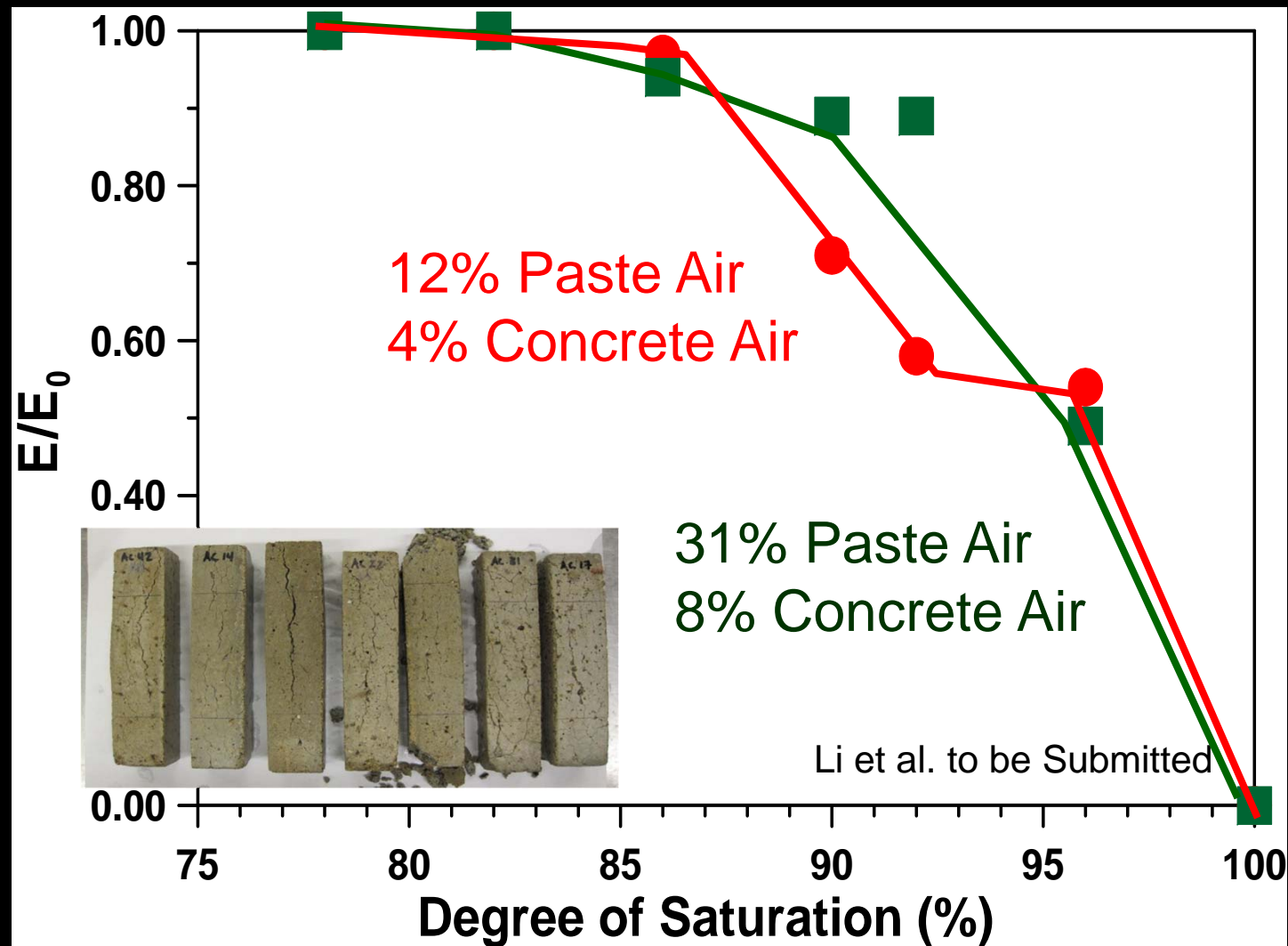


- Freezing and thawing
 - 6 DOS: 96%, 92%, 90%, 86%, 82%, 78%
 - 1 cycle per day (10°C to -18°C)
- Acoustic emission
 - Passive: acoustic energy
 - Active: transmission time (wave speed)
 - Active: relative dynamic elastic modulus





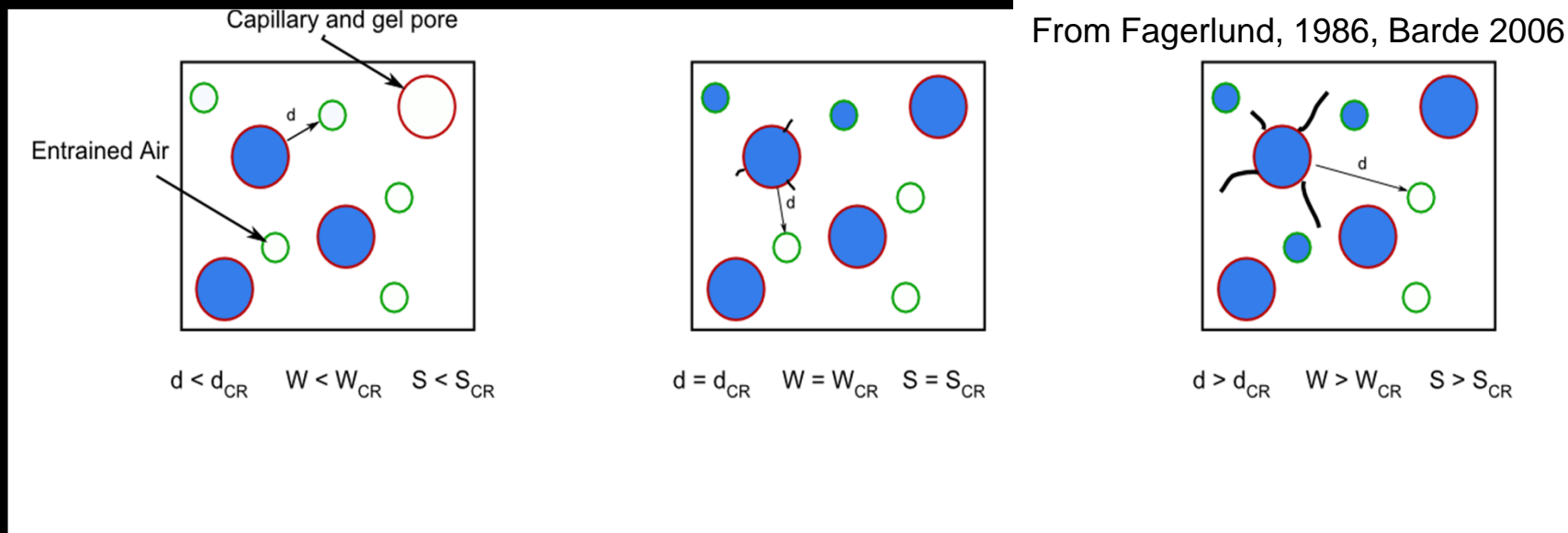
Relative Dynamic Modulus (N=6)



Li et al. to be Submitted



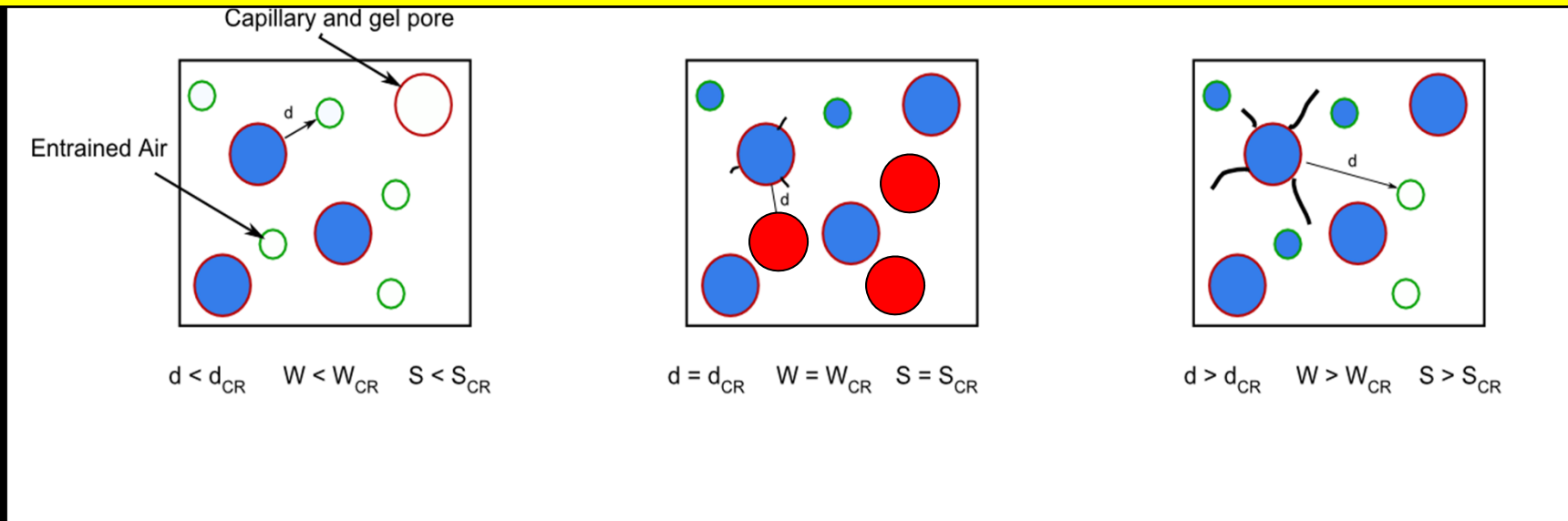
SPR 2941 – Freeze Thaw Damage Damage Modeling Concepts



- Conventionally it is assumed that concrete is becoming more saturated as water enters
- There is a volume and minimum spacing the critical feature is DOS not air volume



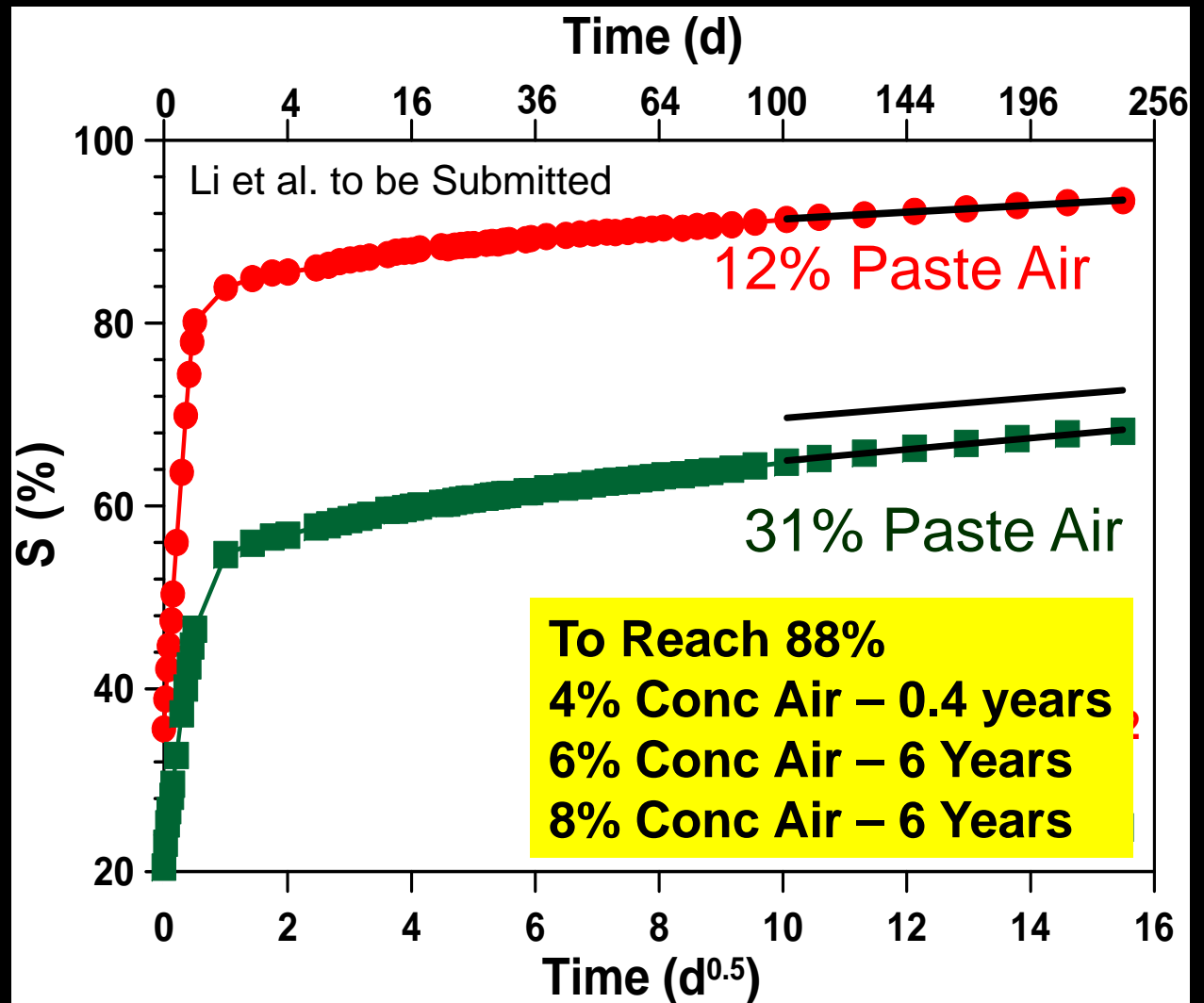
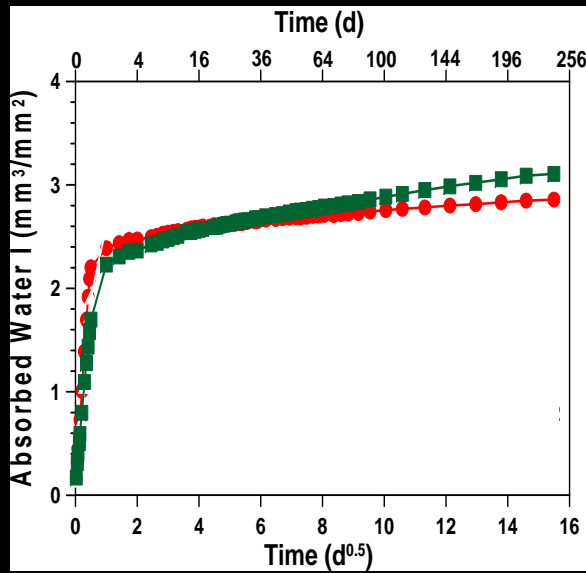
SPR 2941 – Freeze Thaw Damage Modeling Concepts



- Conventionally it is assumed that concrete is becoming more saturated as water enters
- Olek et al shows the pore space reduces over time as well resulting in 'critical condition'

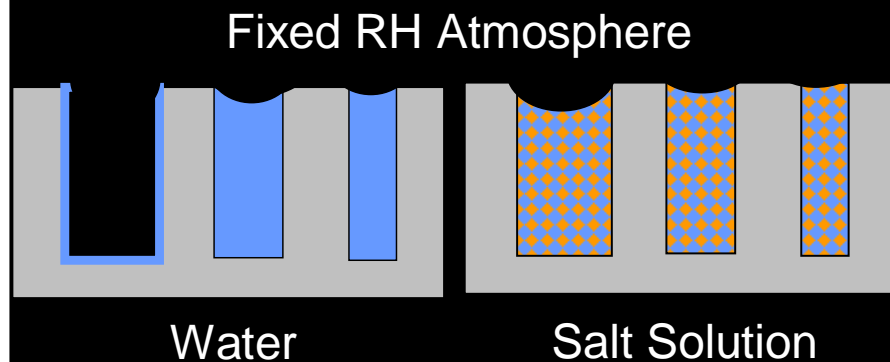
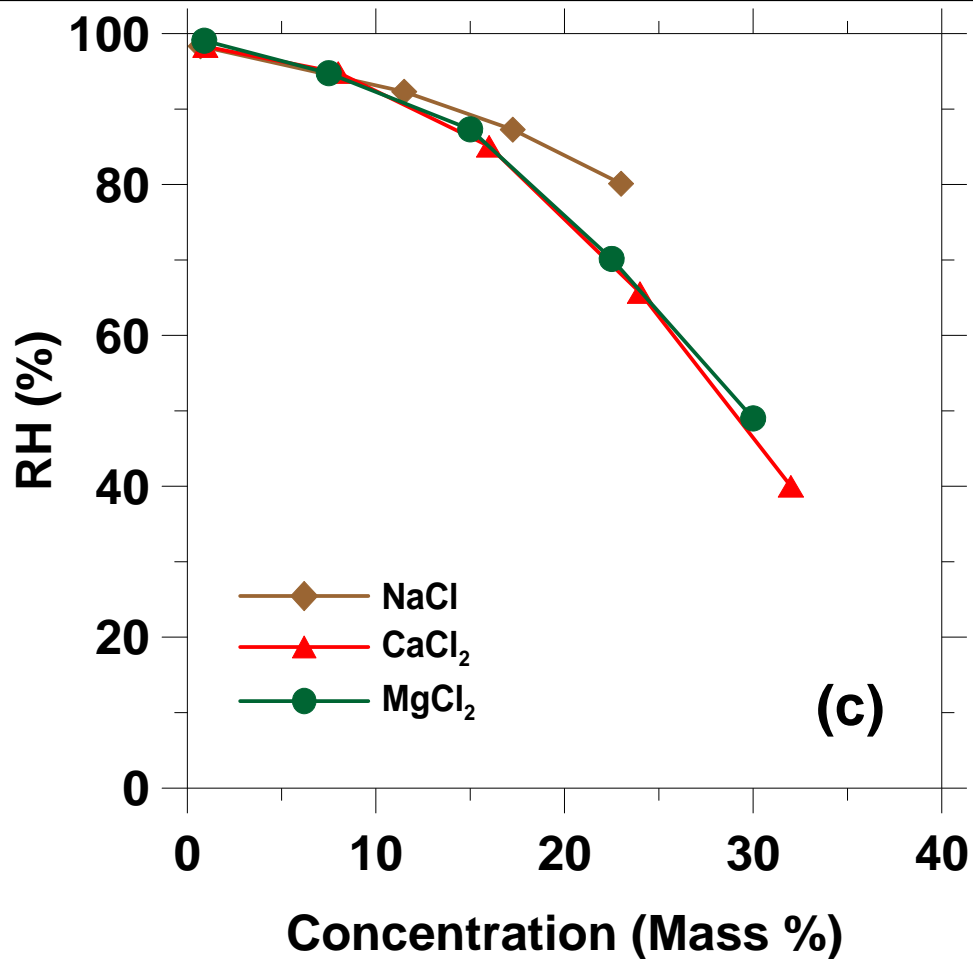


Degree of Saturation





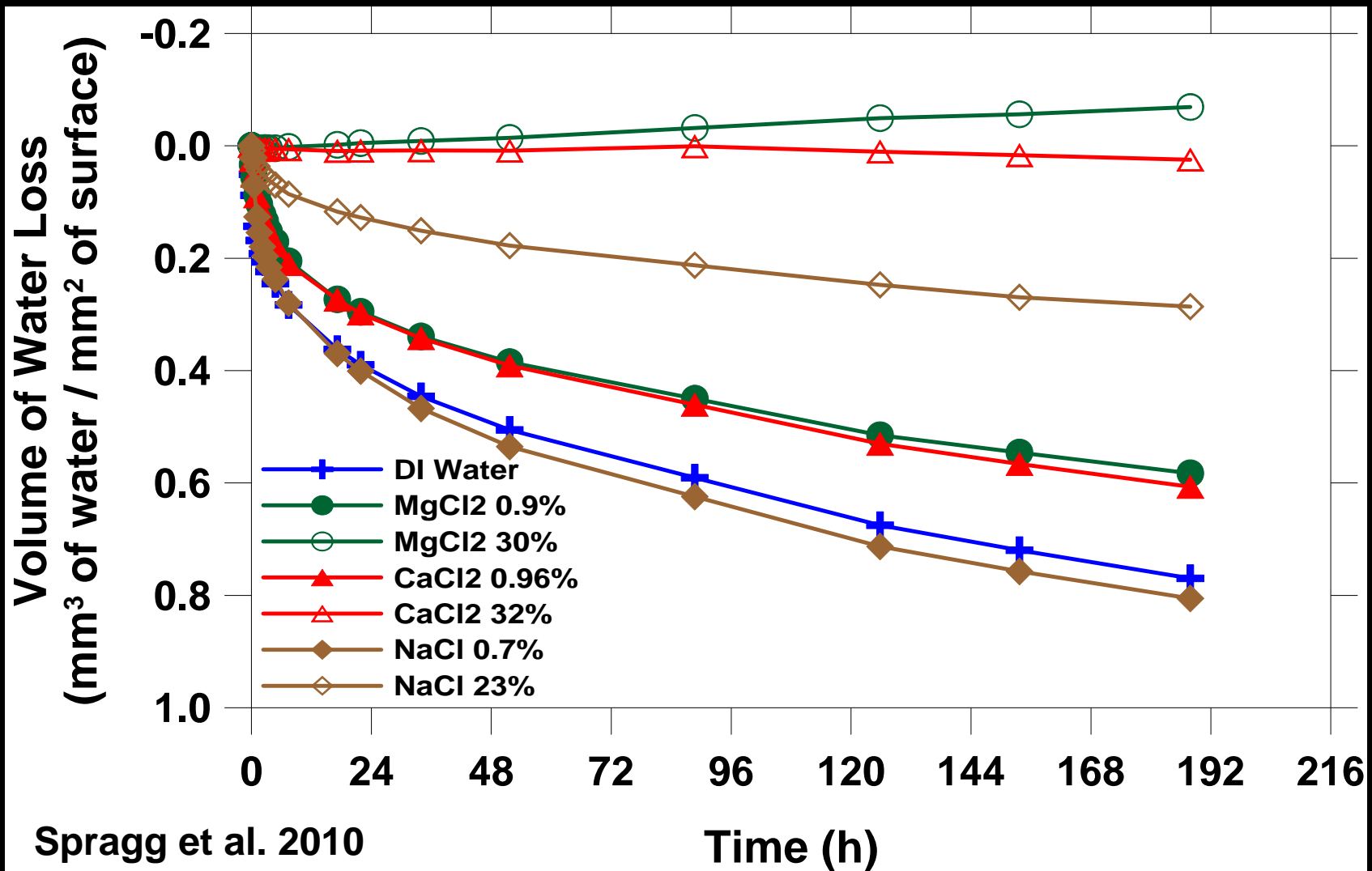
Relative Humidity Measurements



Spragg et al. submitted 2010



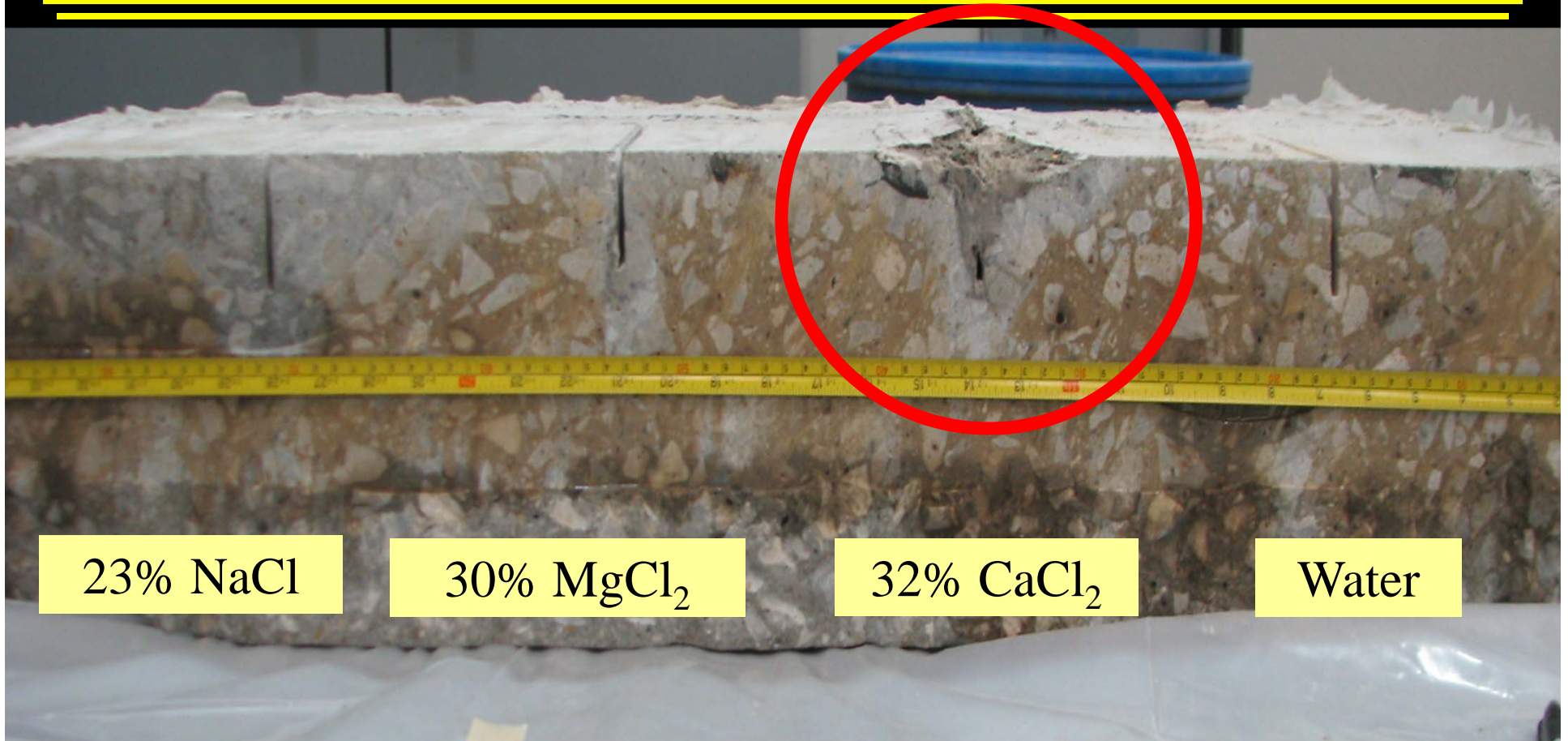
'Drying' with Salts



Spragg et al. 2010



Damage in Saw Cut Slab Test



23% NaCl

30% MgCl₂

32% CaCl₂

Water

No Sealer – 4 different Soaking Solutions (56 Days).

Awaad et al. 2010



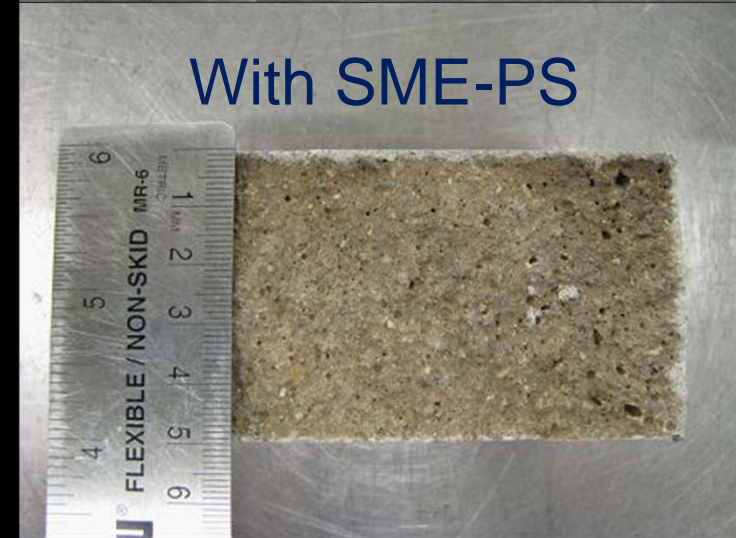
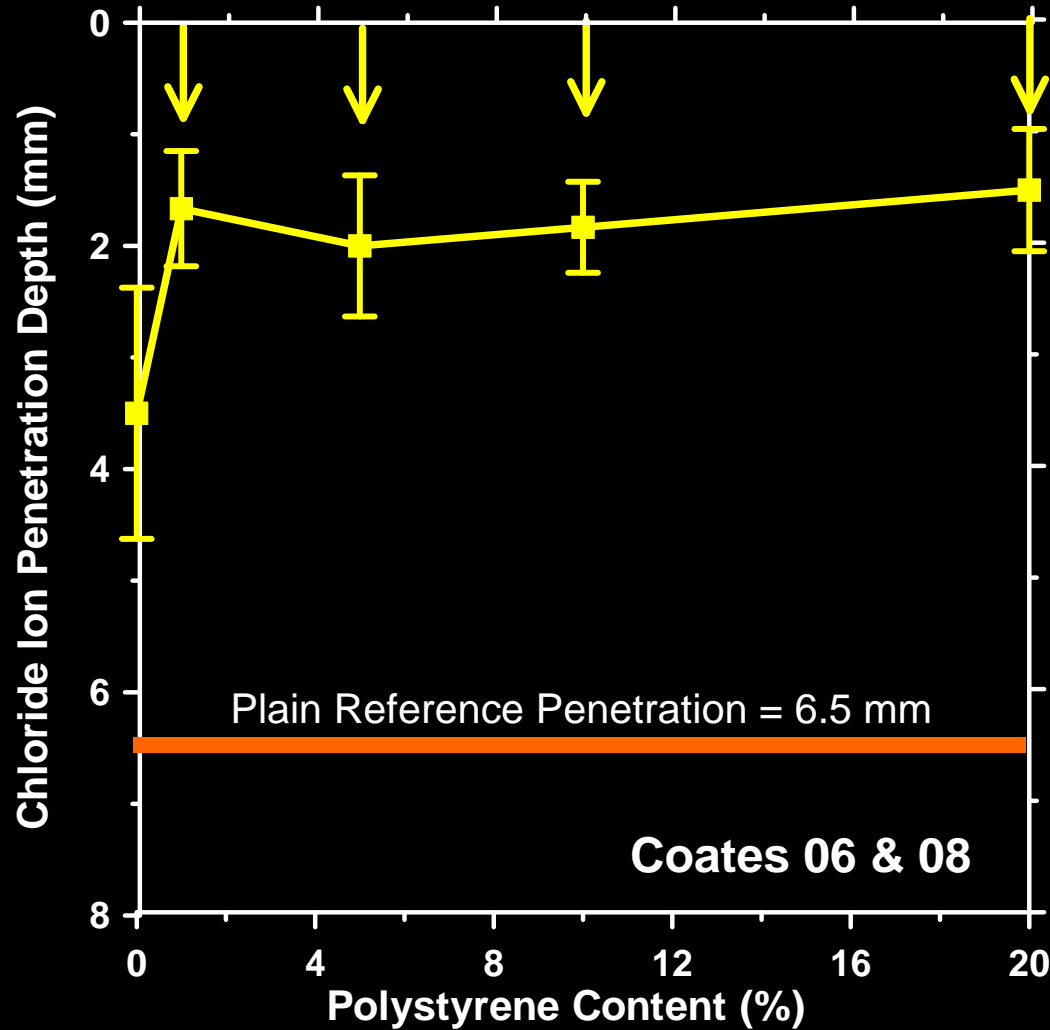
Task: Evaluate Sealer, Pore Blockers and Water Repelling Materials



- Develop a testing methodology that assesses the impact of sealers, pore blockers and water repelling materials on delaying or preventing signs of concrete-salt-moisture deterioration.
- Develop a protocol for evaluating different sealers, pore blockers and water repelling materials.
- Develop specification language for material qualification and application for pavements with signs of concrete-salt-moisture deterioration.
- The work will evaluate the properties of the fluids that bear the salt and the impact of these properties on ingress.



Chloride Penetration

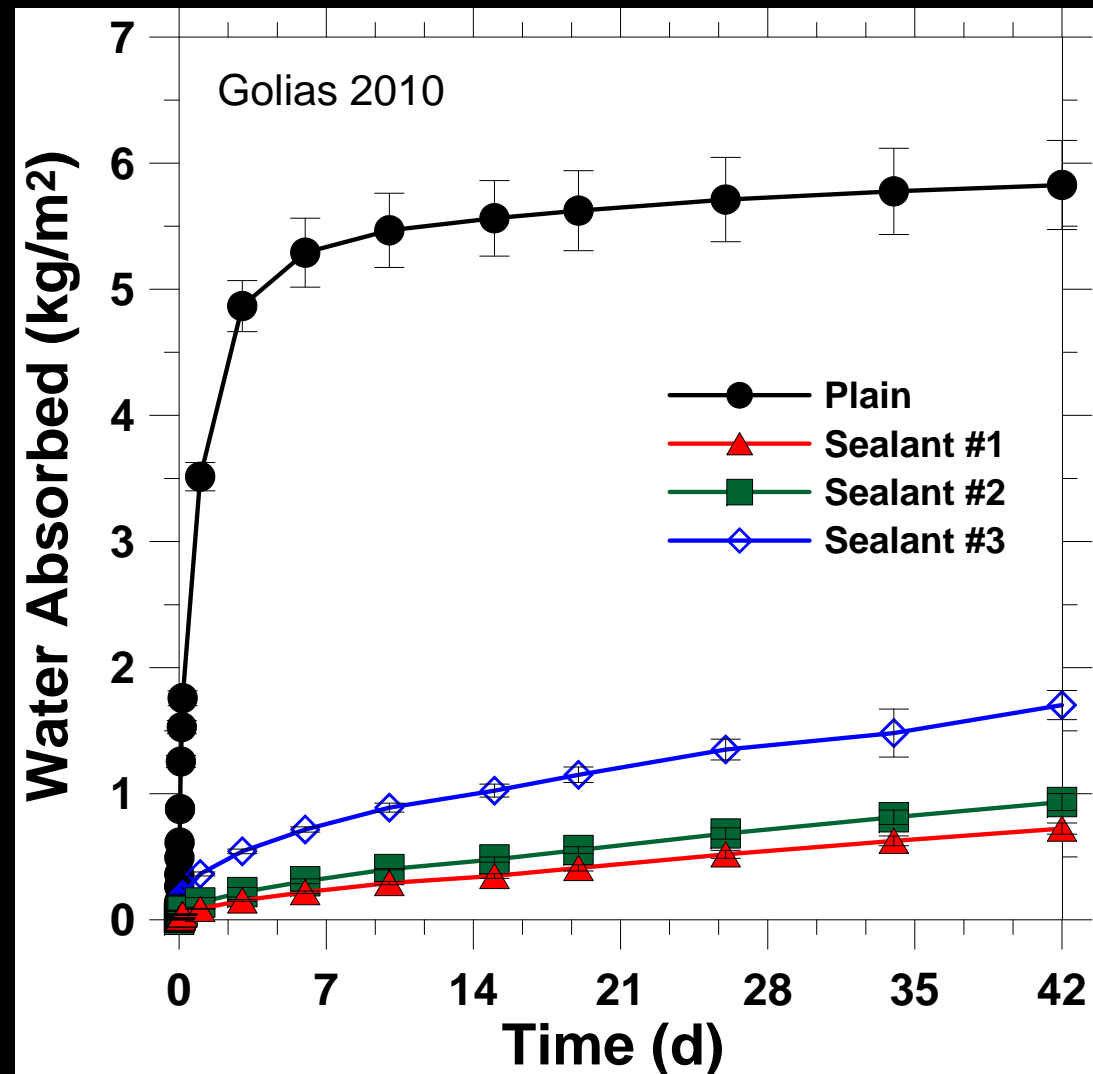




Water Absorption

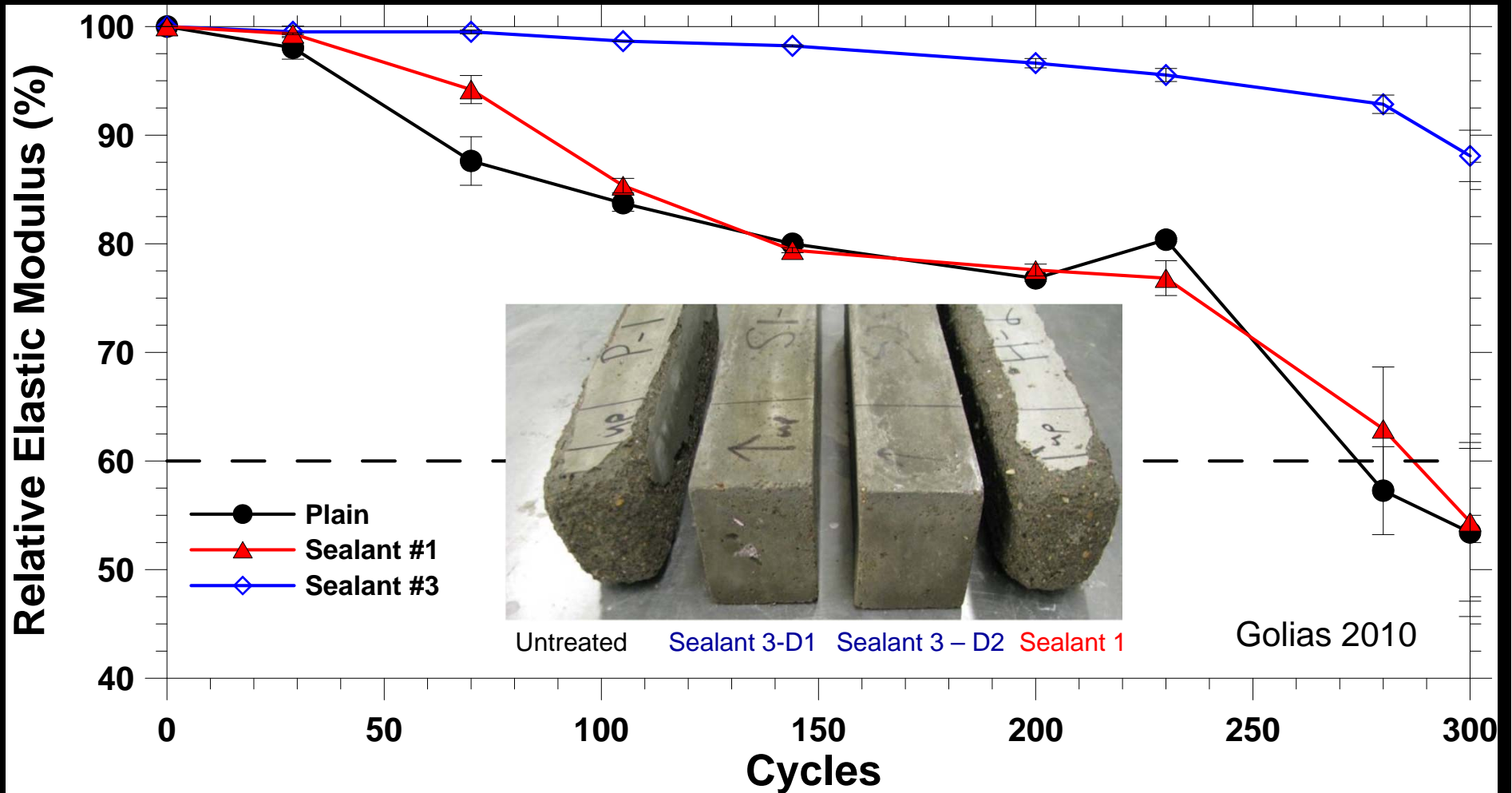


- All sealants effective at reducing the amount of water absorbed
- At 42 days (6 weeks)
 - 83% reduction with sealants #1 and #2
 - 75% reduction with sealant #3



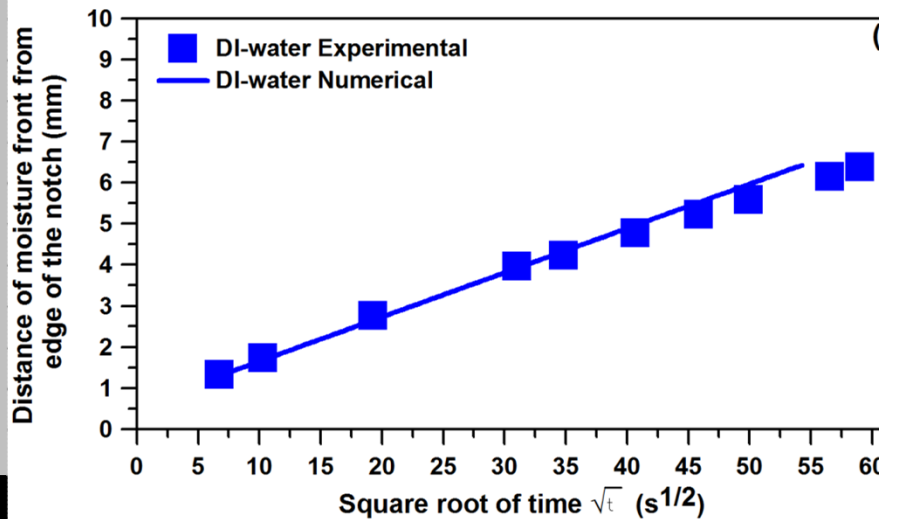
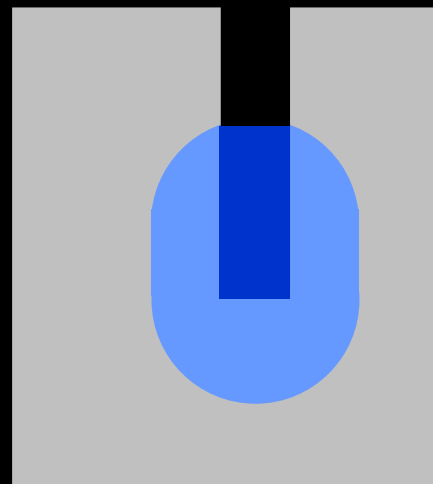
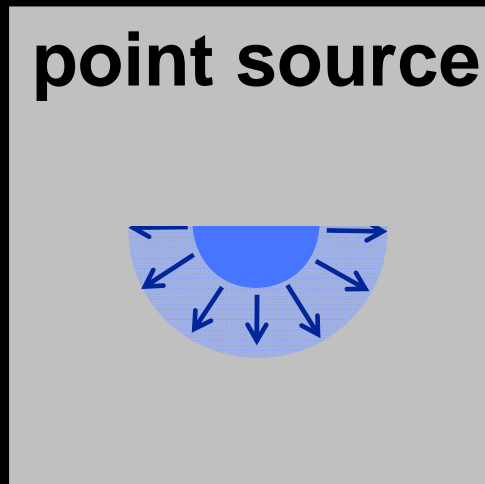
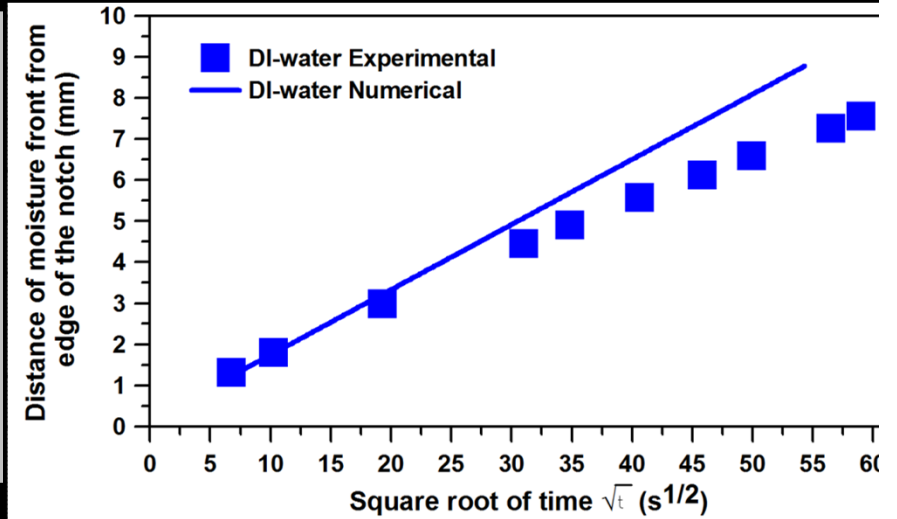
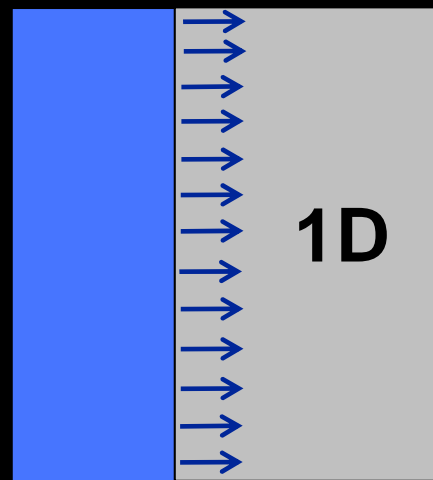
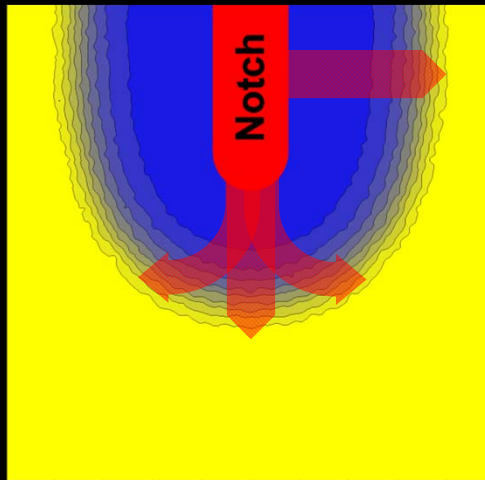


Freeze-Thaw Durability (ASTM 666A)





Source Geometry

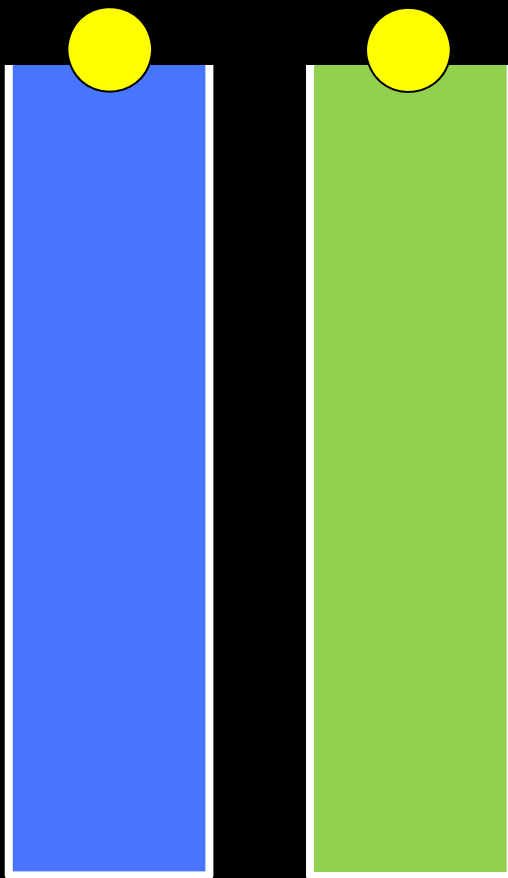


Pour Ghaz et al. 2009

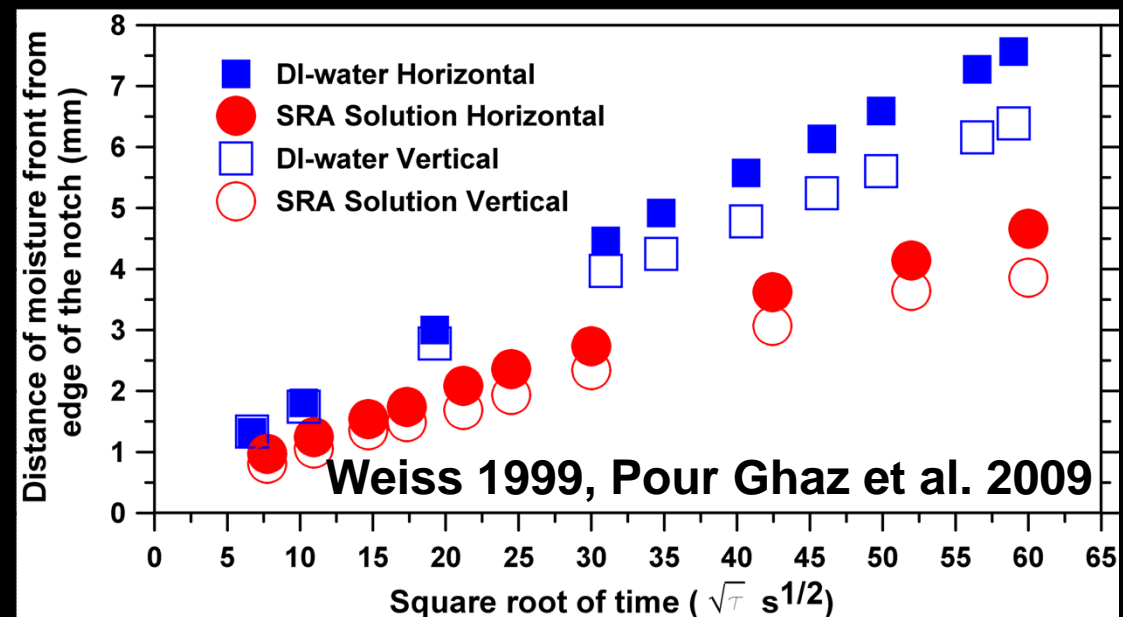


Viscosity

- Diffusion slower
- Absorption slower

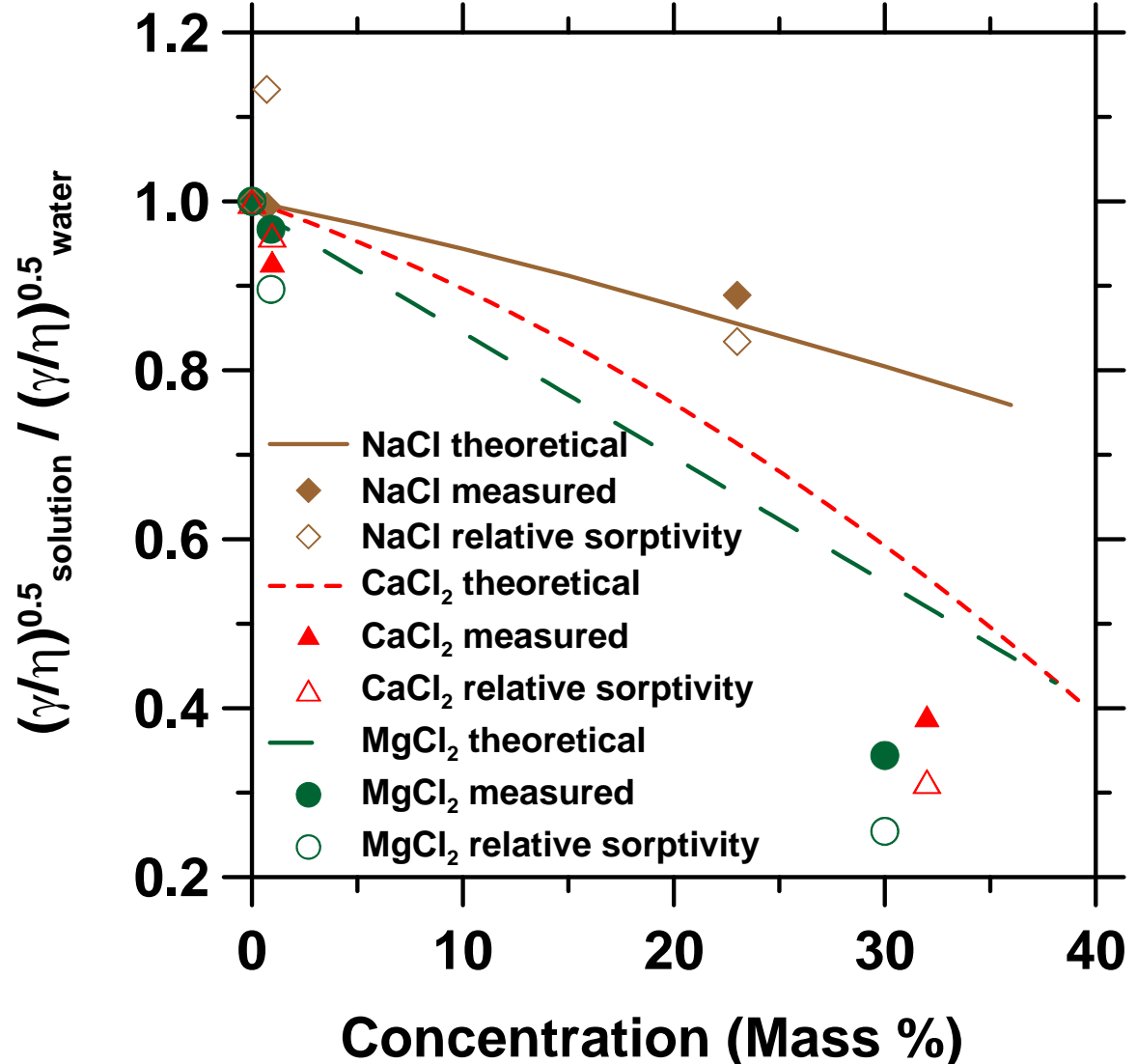
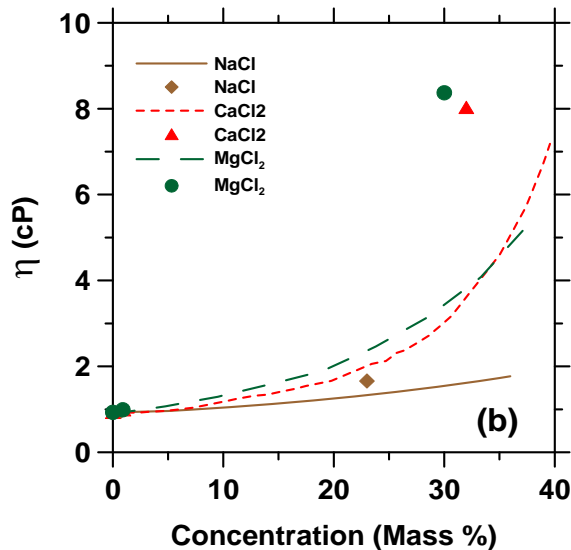
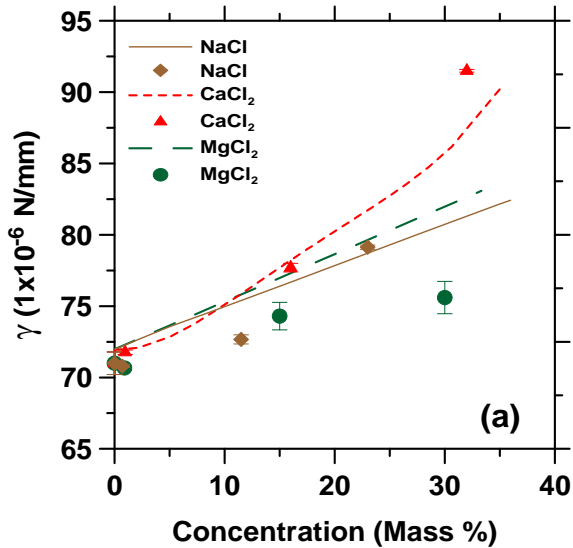


$$x(\tau) = \sqrt{\frac{4 k \gamma \cos(\theta) \tau}{\phi \eta r}}$$



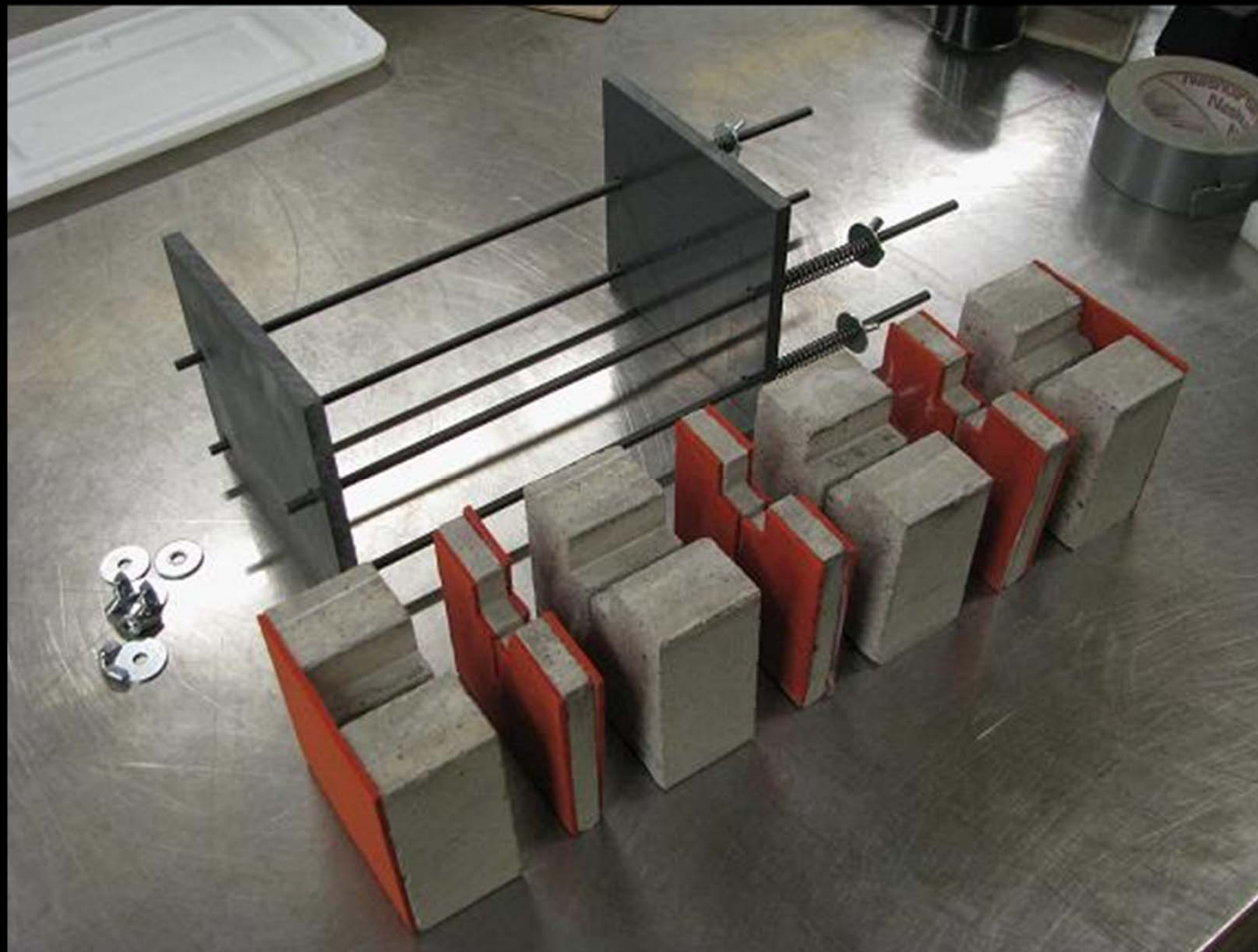


Why is Viscosity Important Sealers and Salts





Beginning Work on Early Damage Detection Approaches





Summary



- Hypothesis Plausible – Absorption to Saturation then Damage is Instantaneous
- Air Delays the Rate of Saturation
- Salts have slower absorption & alter drying
- Recent investigations of sorption important
- Sealers appear to work but discrepancies are noticed with temperature (working hypothesis to separate sealers)
- Modeling work nearing a point where we have a sufficient idea of inputs