

Internal Curing Concrete

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With thanks to:

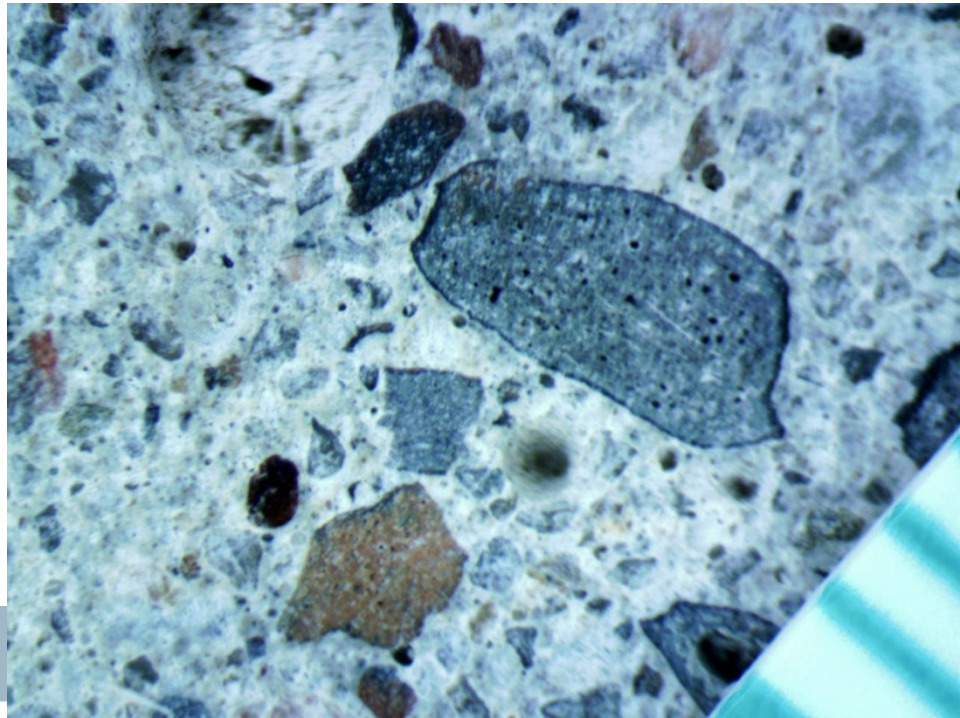
John Ries, ESCSI

Dale Bentz, NIST

Jason Weiss, Oregon State

Internal Curing

- Why?
- How?
- So What?



Internal Curing - Why

- Curing is promoting hydration by
 - Providing water
 - Keeping it warm

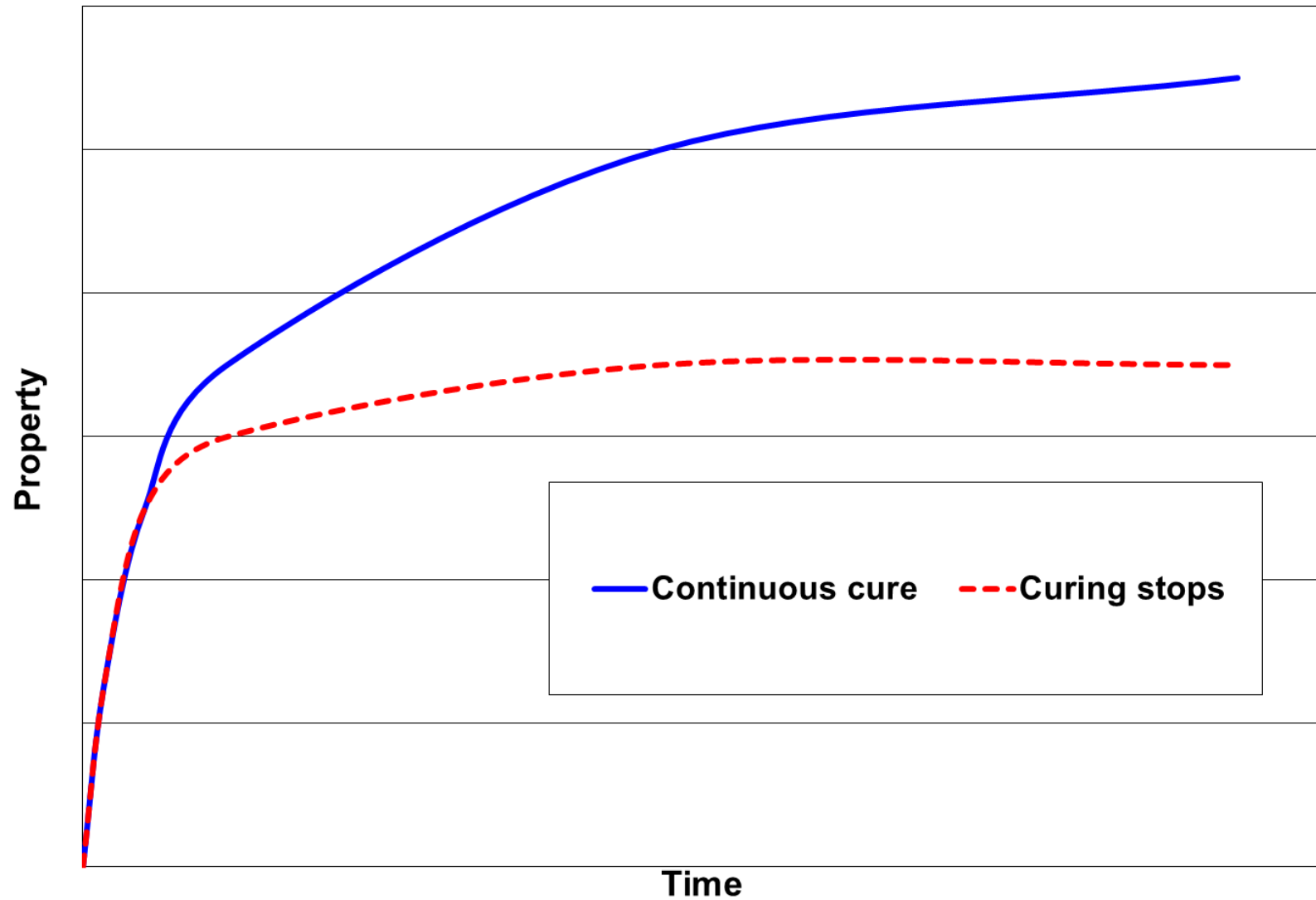


Internal Curing - Why

- Without curing we will increase risk of
 - Cracking
 - Scaling
 - A soft surface
 - Warping
- What about strength?

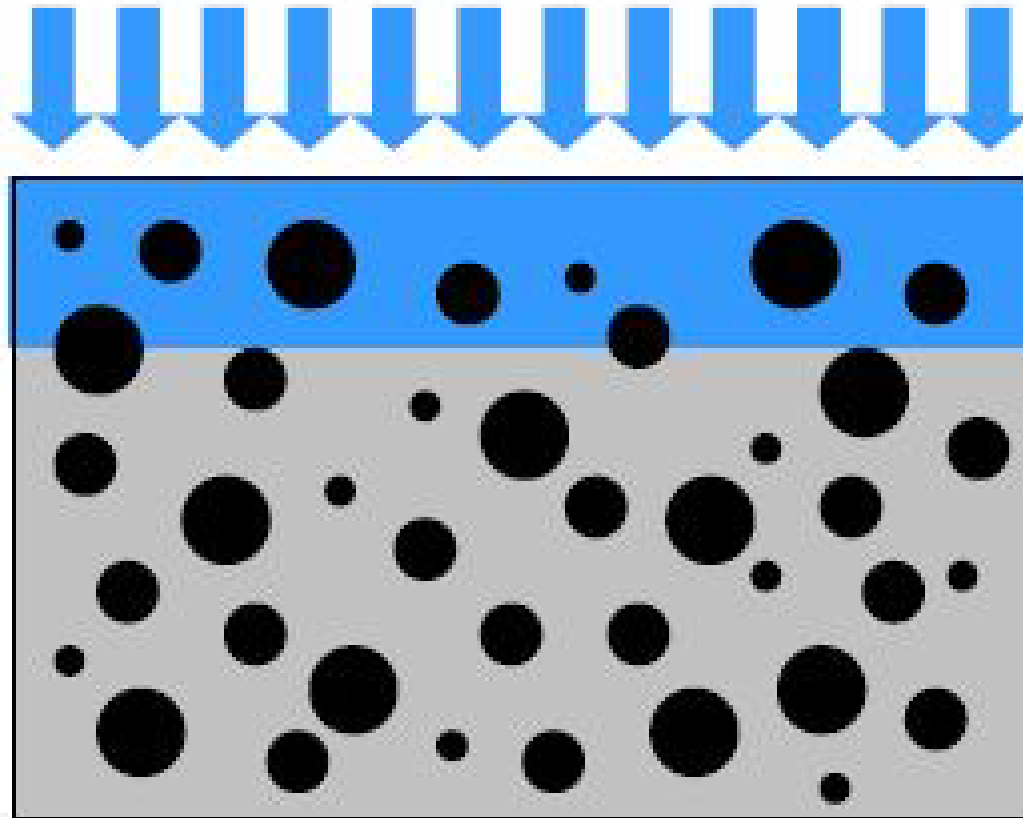


Internal Curing - Why



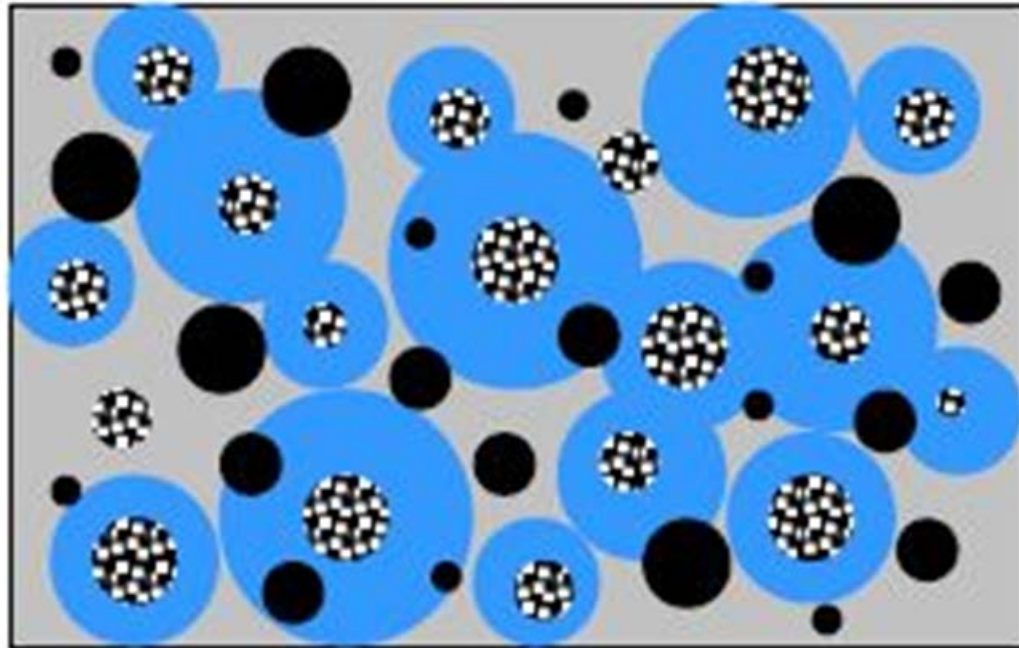
Internal Curing - Why

External water



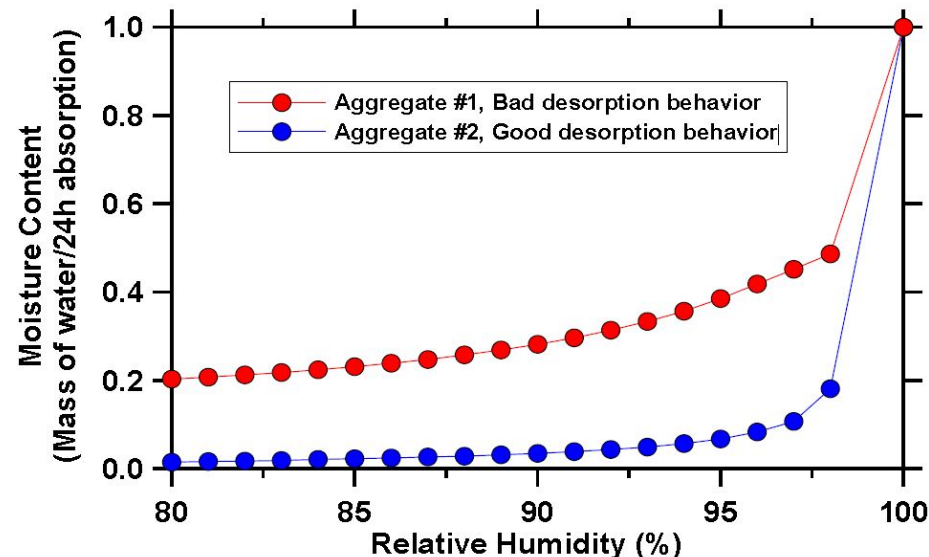
Internal Curing - Why

Internal water



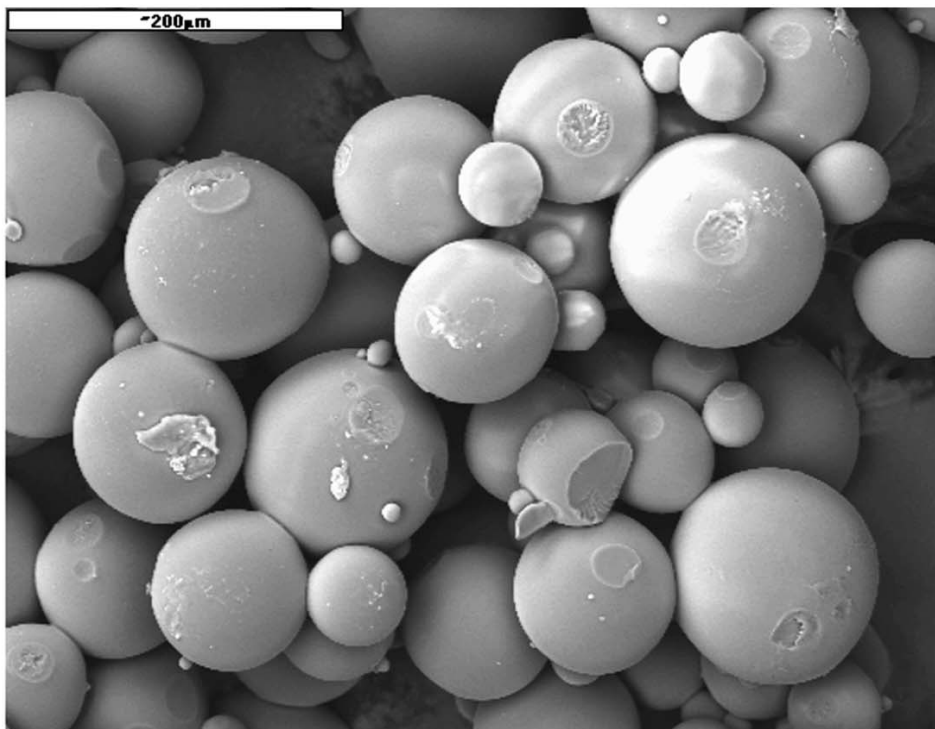
Internal Curing - How

- Material should
 - Hold sufficient water
 - Hold the water until needed and not effect w/c
 - Give up water at high RH (desorption)
 - Not adversely effect the concrete quality



Internal Curing - How

- Lightweight fine aggregate
- Super Absorbent Polymers



Simple IC Mixture Design

- Need **7 lbs** of IC water per 100 lbs of cementitious
- 600 lbs cementitious = 42 lbs of IC water
- Assume 18% LWA absorption in the field
- Assume LWA at 55 lbs/cf
- $55 \times .18 = 9.9$ lb/cf water
- 90% desorption = 8.9 lb/cf water
- Need 42 lbs IC water / 8.9 = 4.7 cf of LWA
- $4.7 \text{ cf} \times 55 \text{ lb/cf} = 259$ lbs of LWA aggregate

Guide Specification

- In preparation
 - QC is critical
 - Minimum 15% absorption
 - Monitor moisture state of LWFA and adjust mixture
 - Monitor strength and formation factor

Guide Specification for Internally Curing Concrete

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The LWFA should be wet

- Place under sprinkler for minimum of 48 hours
- Allow stockpiles to drain for 12 to 15 hours immediately prior to use
- Measure absorption before batching



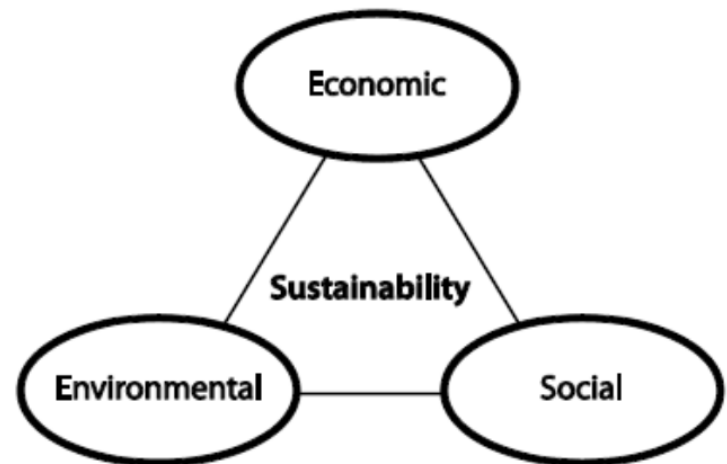
Internal Curing - How

- Can we do without this?
- Nope
 - Still have to keep the surface hydrating
 - That's where the abuse happens



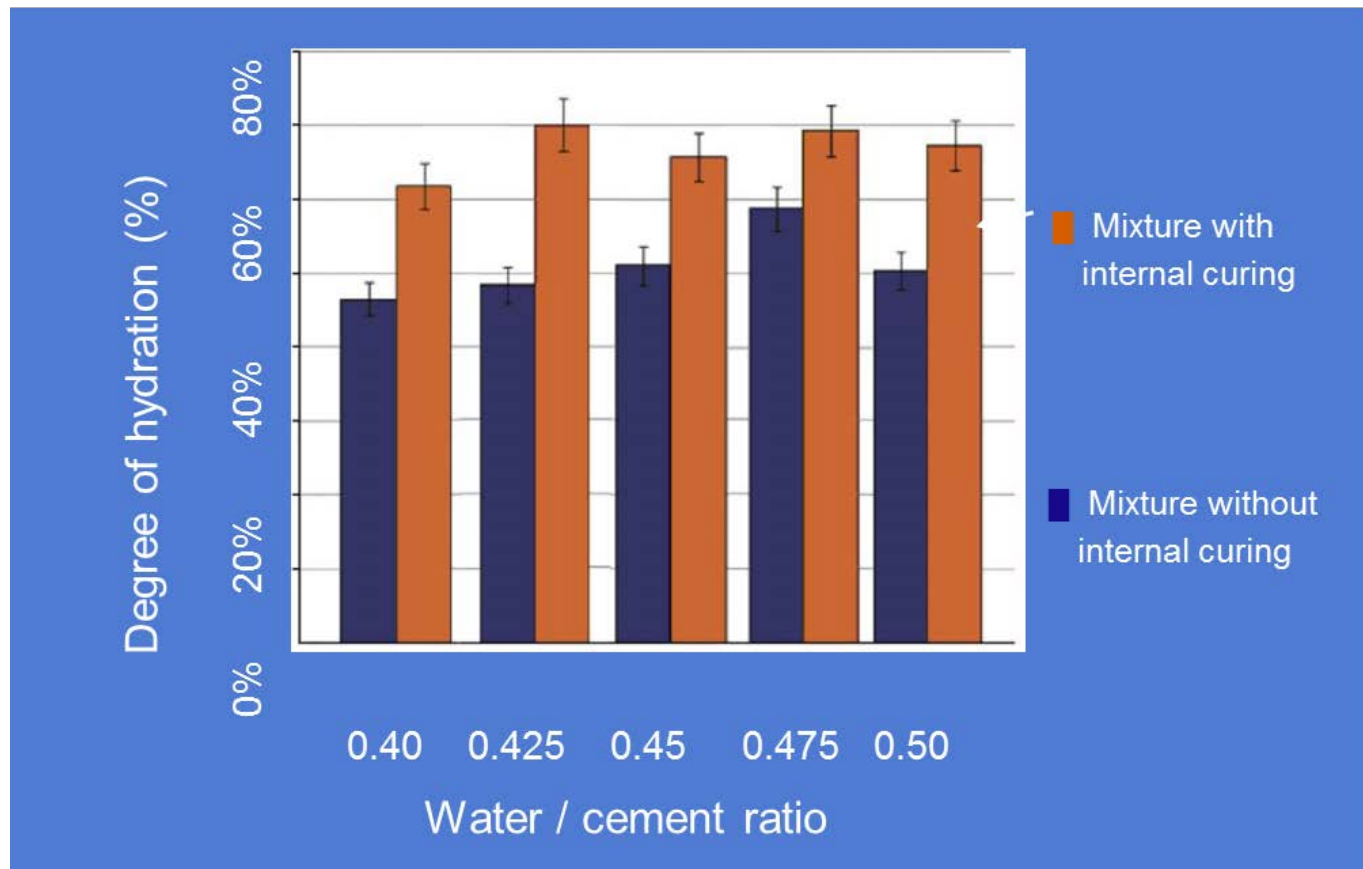
Internal Curing - So What

- Benefits
 - Better hydration & SCM reaction
 - Improved durability
 - Less cement
 - Less shrinkage, warping, cracking
 - Extended service life
 - Improved economics
 - Increased sustainability



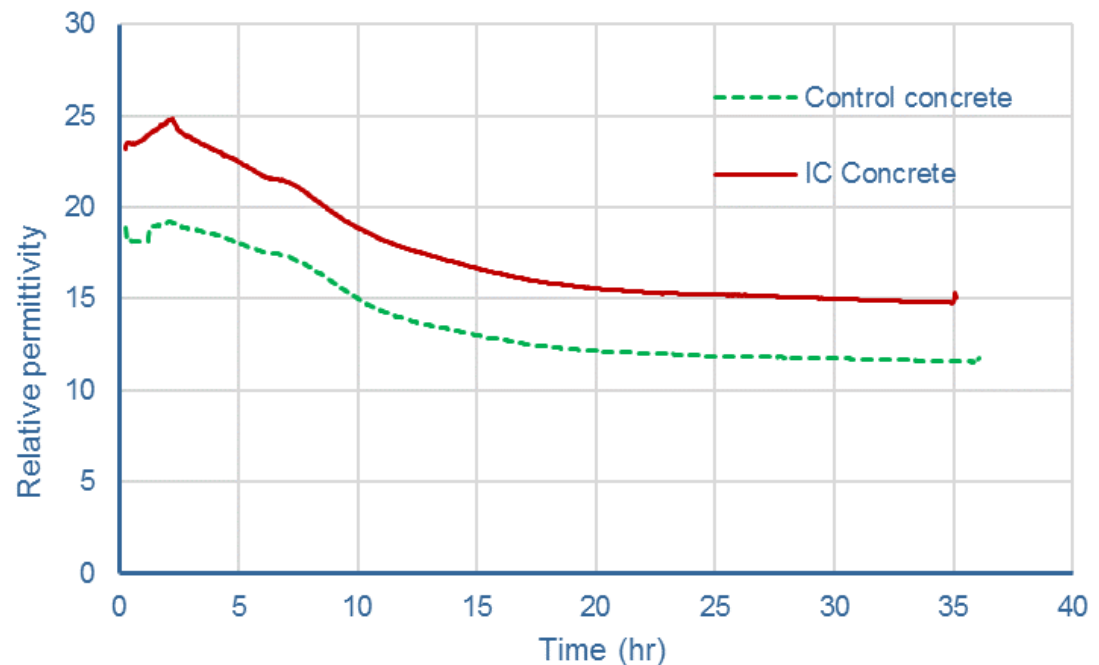
Internal Curing - So What

- More Hydration



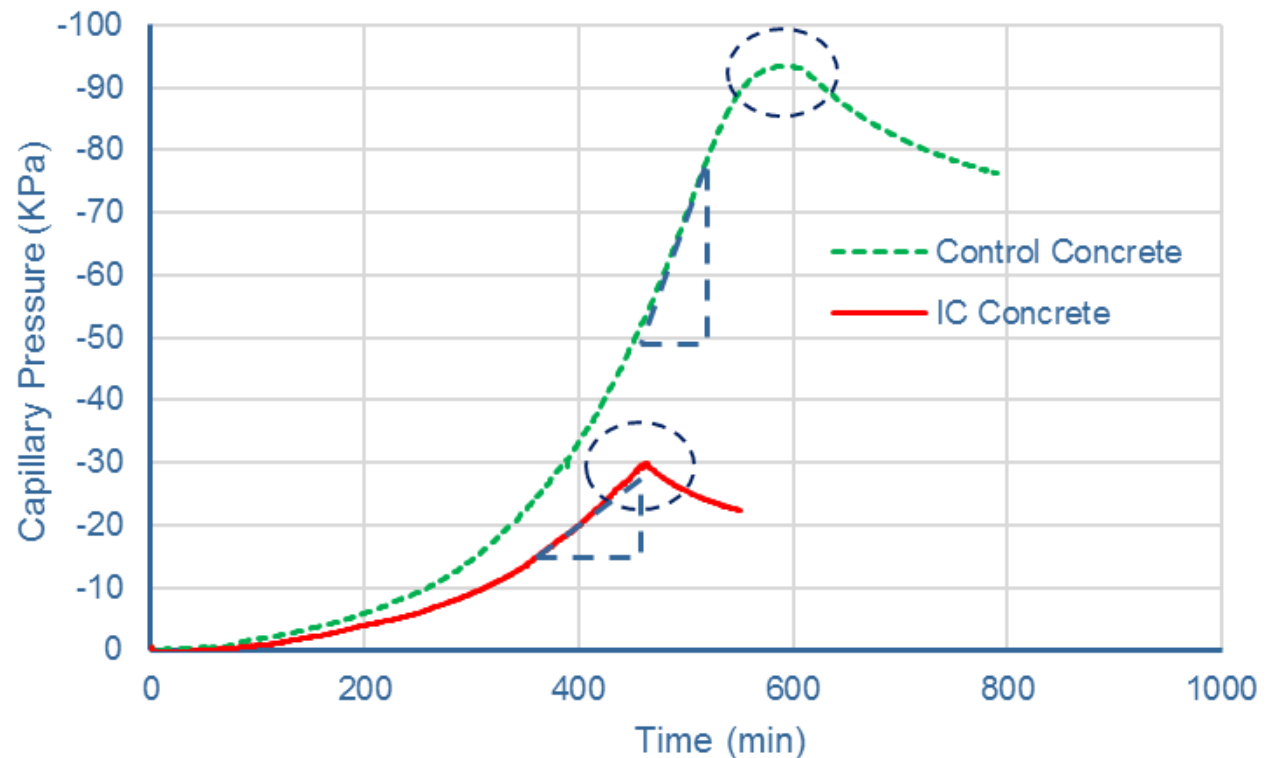
Internal Curing

- Relative permittivity (RP) of fresh concrete
 - RP of water is 20 times higher than other components
 - Therefore higher RP means higher moisture content



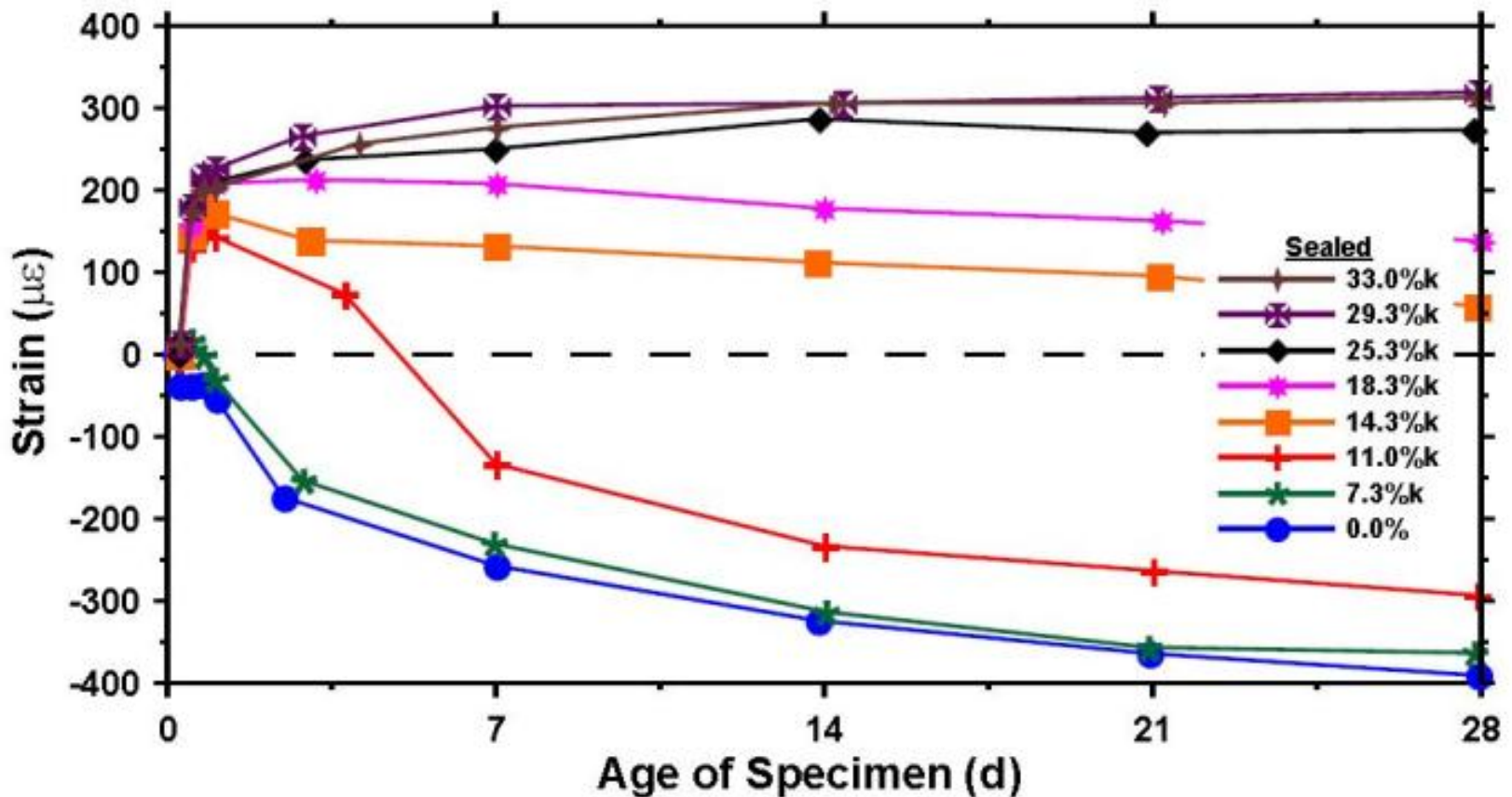
Internal Curing

- Reduced capillary pressure
 - Reduced risk of plastic cracking



Internal Curing – So What

- Less Shrinkage (Sealed)



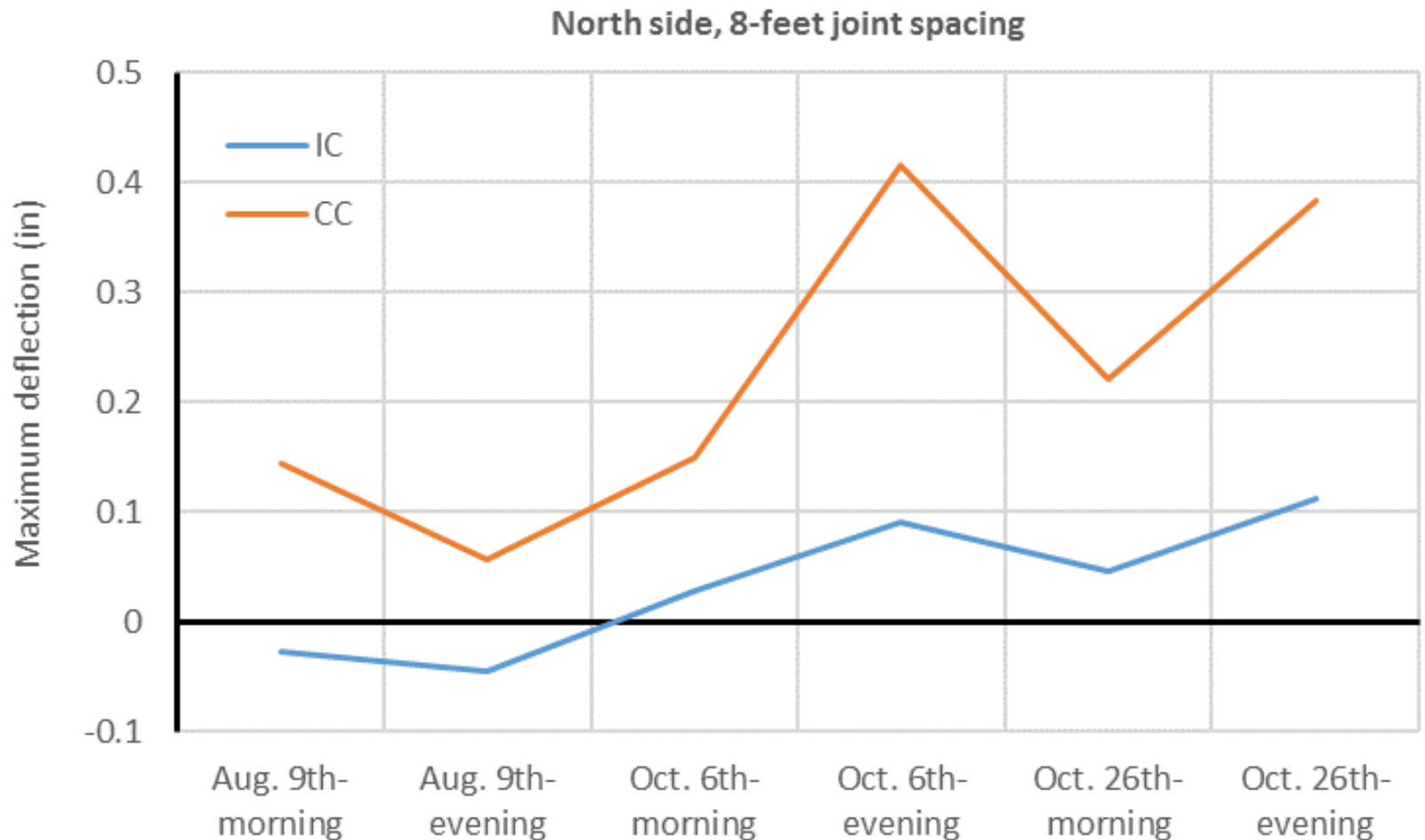
Internal Curing – So What

- Less Shrinkage = Less Cracking



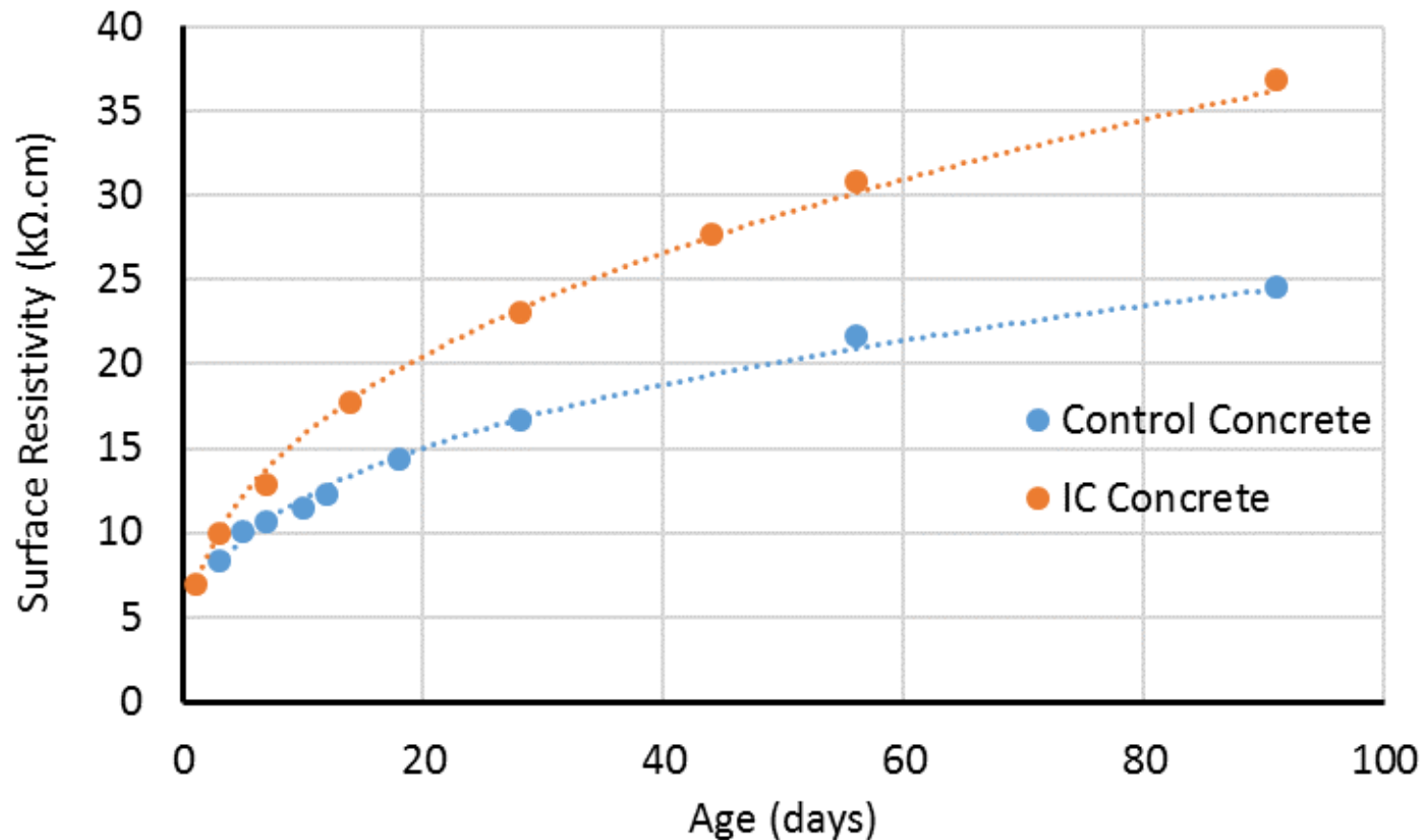
Internal Curing – So What

- Reduced Warping



Internal Curing – So What

- Reduced Permeability



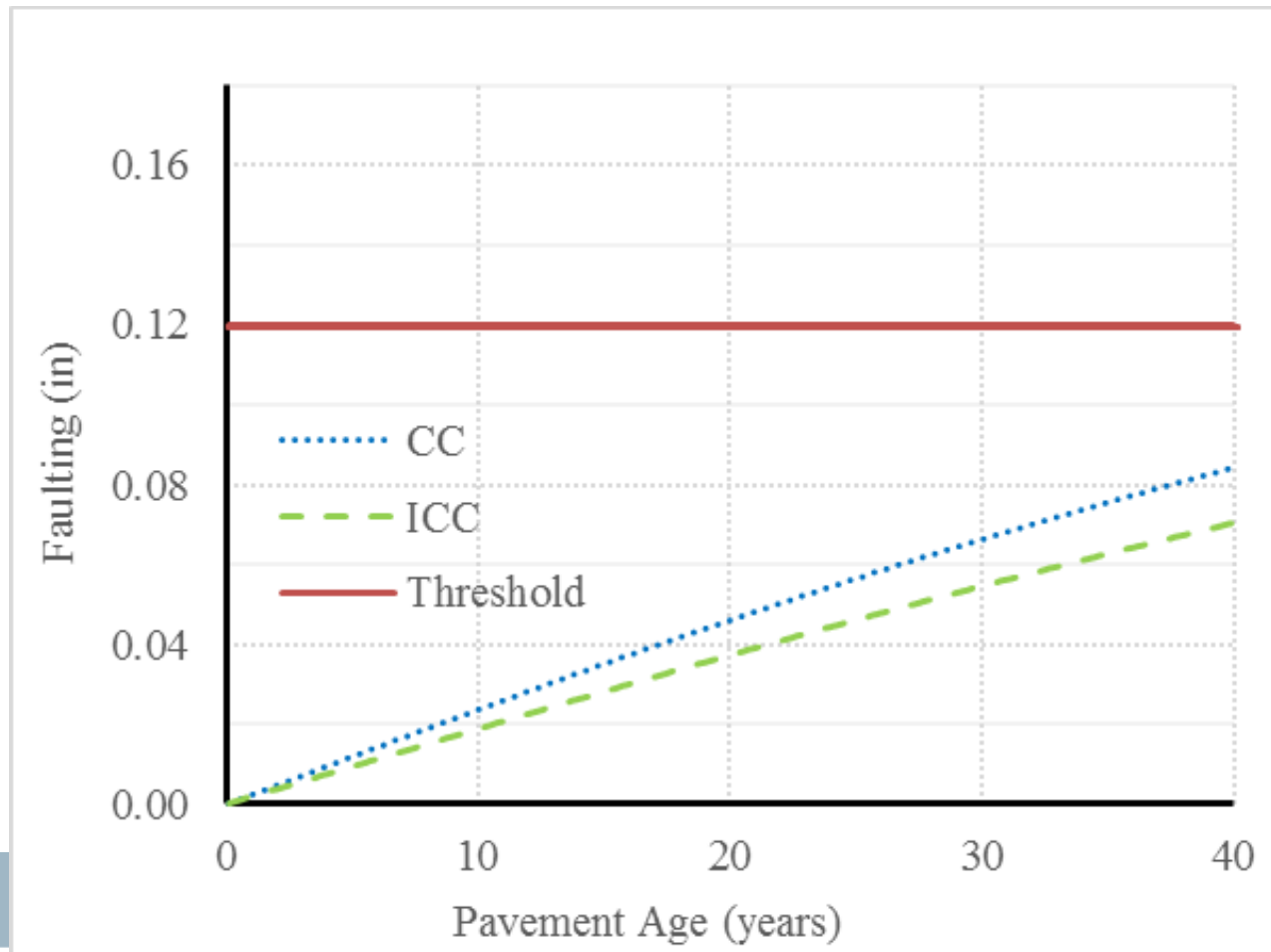
Internal Curing - How

- Looks too easy...
 - Need an extra stockpile
 - It has to be wet
 - Transport?

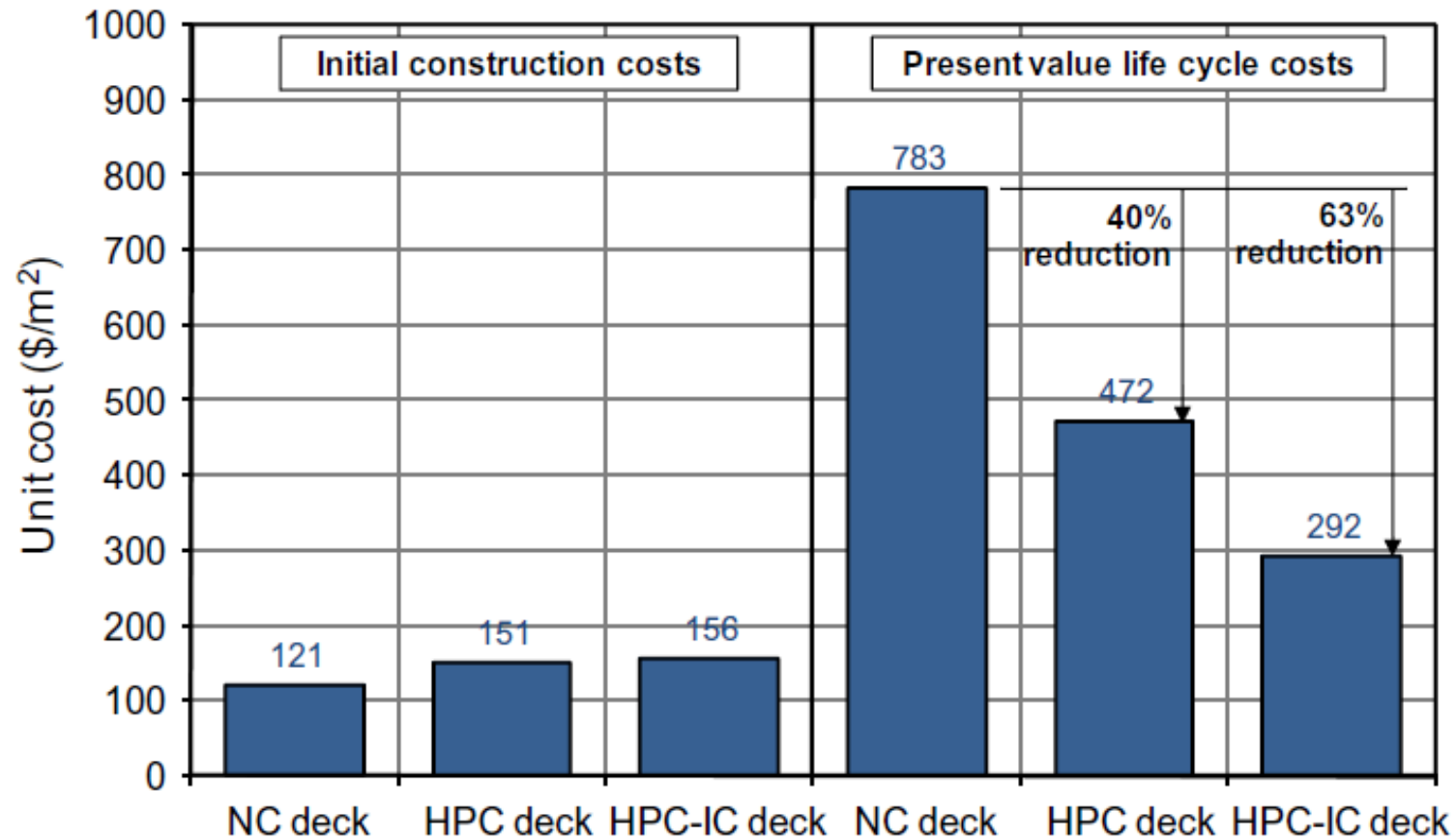


Internal Curing – So What

- Service Life Prediction (MEPDG)



Internal Curing – So What



Buchanan County

- Three span bridge at Pine Creek
 - One half conventional (both lanes)
 - Other half using Internal Curing Concrete
- About 20% (by mass) of fine aggregate replaced with light weight aggregate
- Other mix proportions unchanged



Construction



Looking West – IC placed first

Construction



Hardened Properties

Surface Resistivity, kΩcm							
Age (days)	Laboratory					Field	
	Field samples		Lab samples				
	Control	20% IC	Control	20% IC	30% IC	Control	20% IC
3	7	6.6	6.4	7.3	8.7		
7	9.8	9.2	9.2	10.6	12.6		
28	22.6	22.8	20.9	38.3	51.1		
56	33.3	32.2	31.2	57	74.4		
86	41.1	45.6	42.6			50.3	52.7
365						70.7	73.9

Sidewalk Demonstration



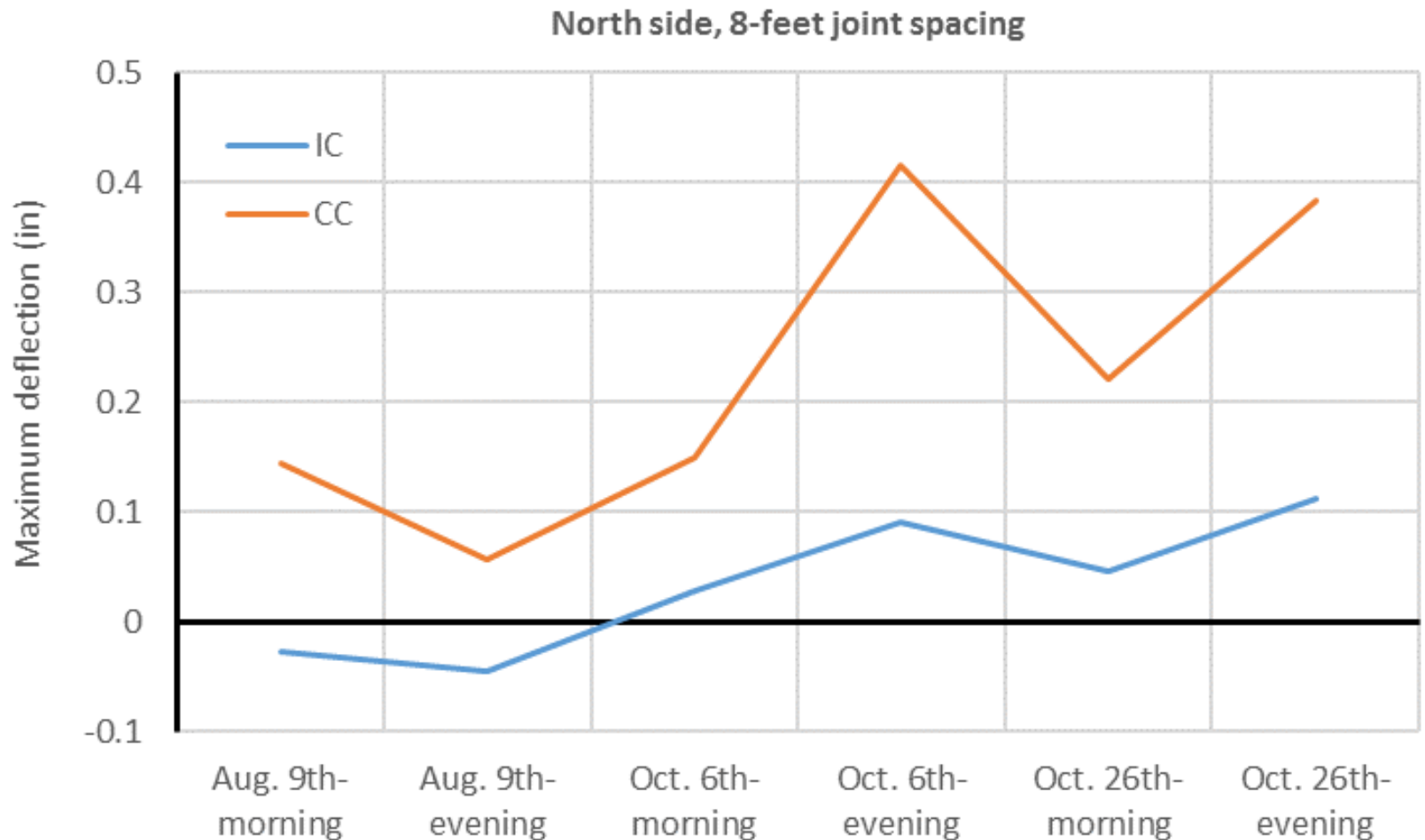
Mechanical Properties

- No significant change in tensile strength
- Slight increase in compressive strength
- Significant decrease in stiffness

	Tensile strength (psi)		Compression strength (psi)		MoE (ksi)	
	28-day	91-day	28-day	91-day	28-day	91-day
Control concrete	505	683	6824	8367	6981	7047
IC concrete	507	698	6925	8430	5461	5489

The Big Story

- Reduced Warping



Closing

- Theoretically sound
- Some construction challenges
- Little change in structural performance
- Helps durability and cracking risk
- Recommended for
 - Bridge decks
 - Thin overlays

“Go do good things”

