Concrete Curing Methods

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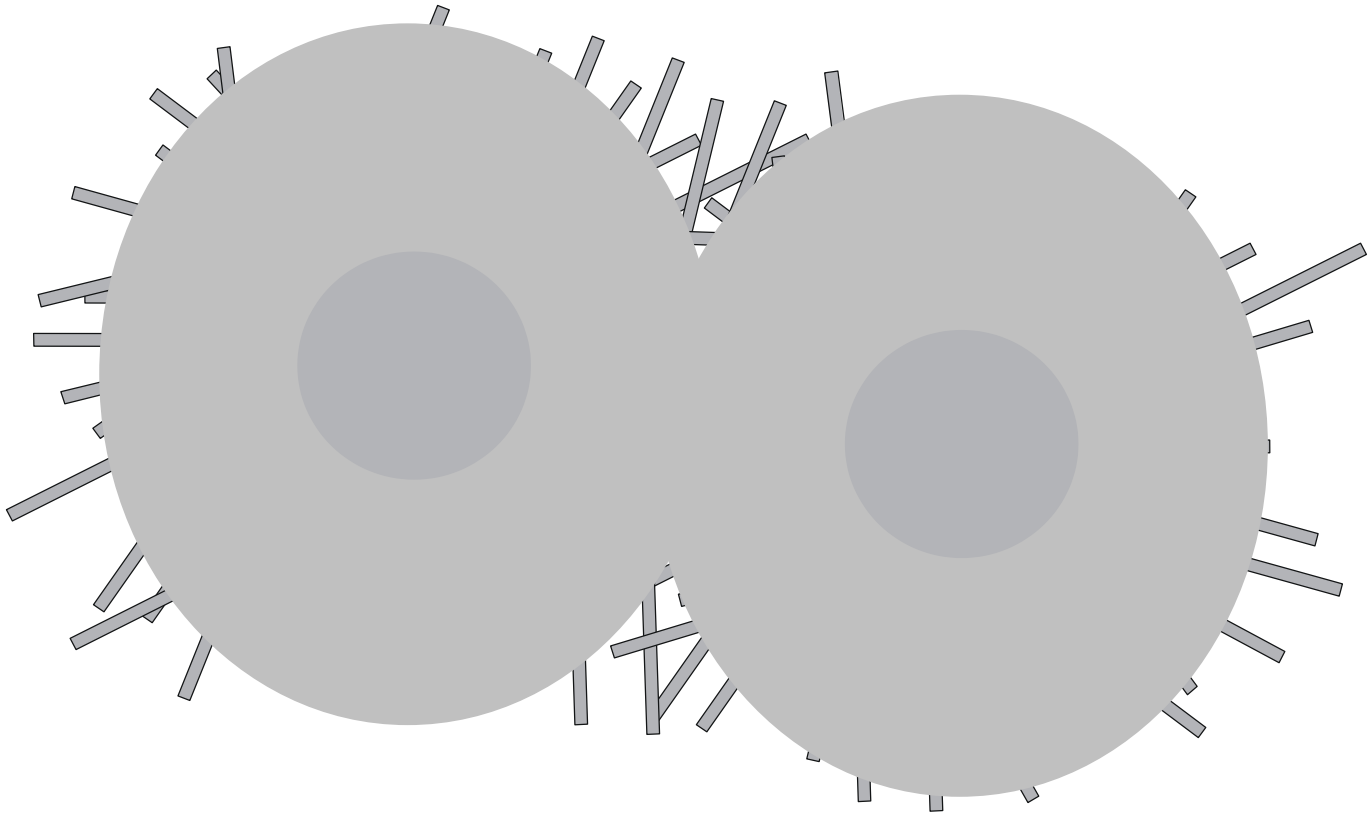
Outline

- Why
- What is it
- **How**
- When
- How much

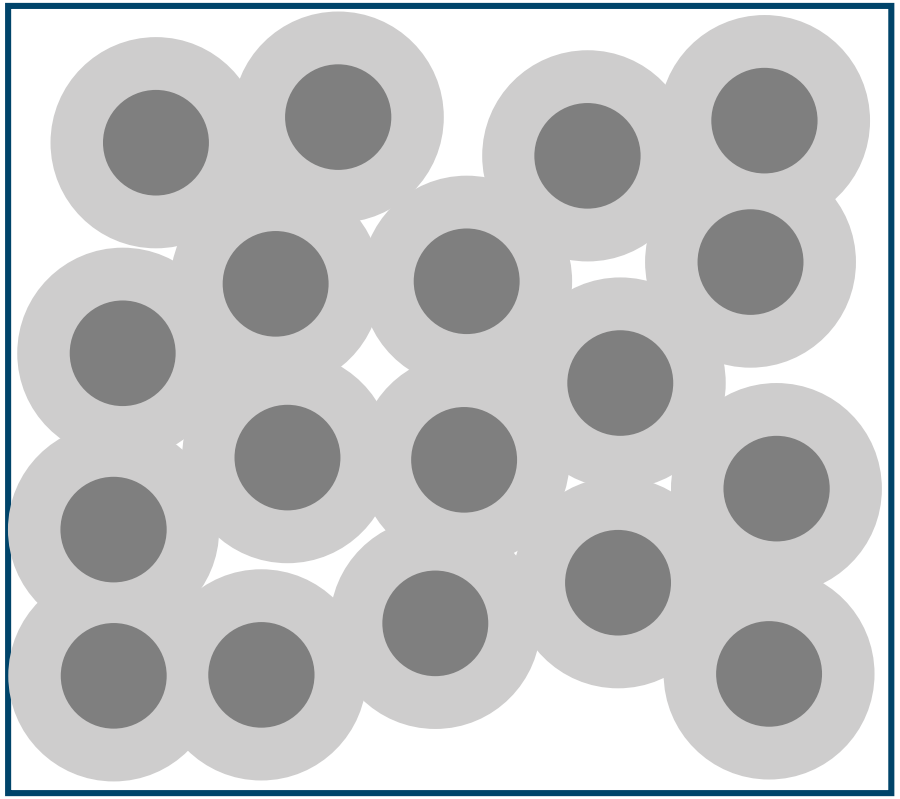
Cement Hydration

- Chemical reactions between cement and water
- Will keep going as long as:
  - Sufficient cement
  - Sufficient water
  - Sufficient temperature

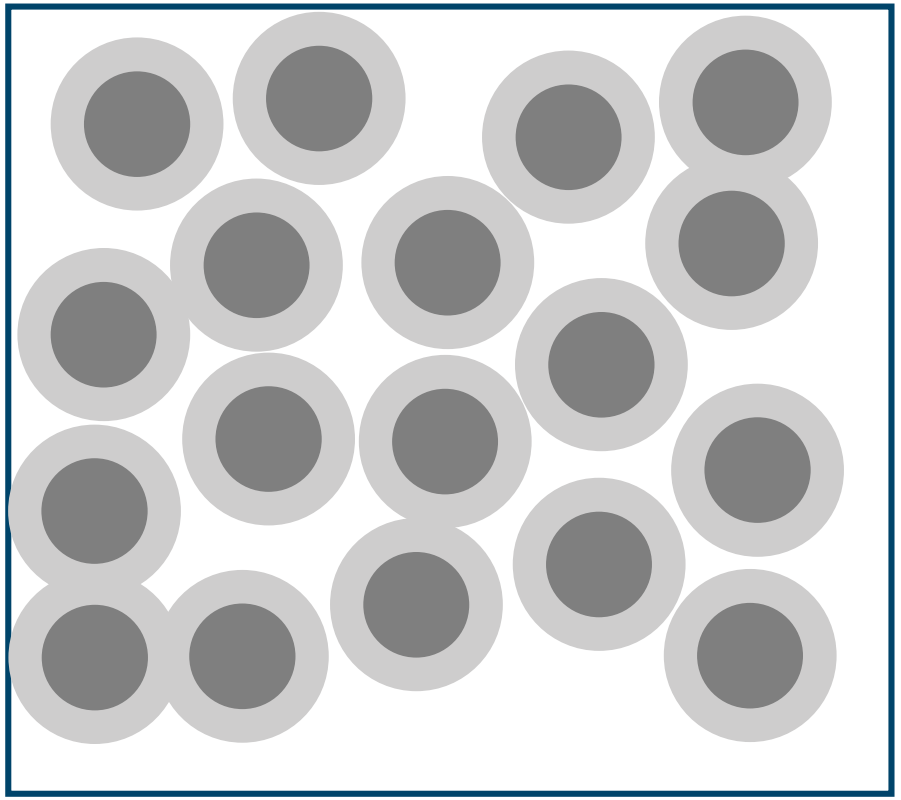


Effect of Curing

Good

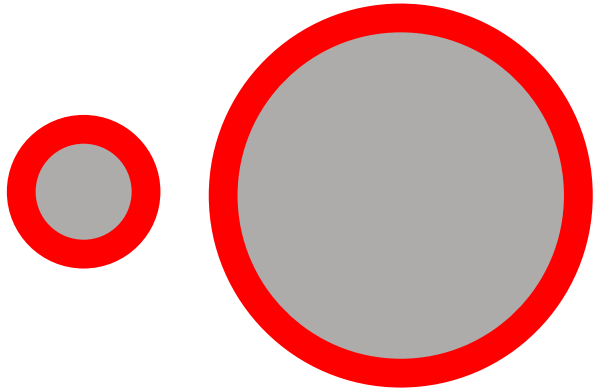


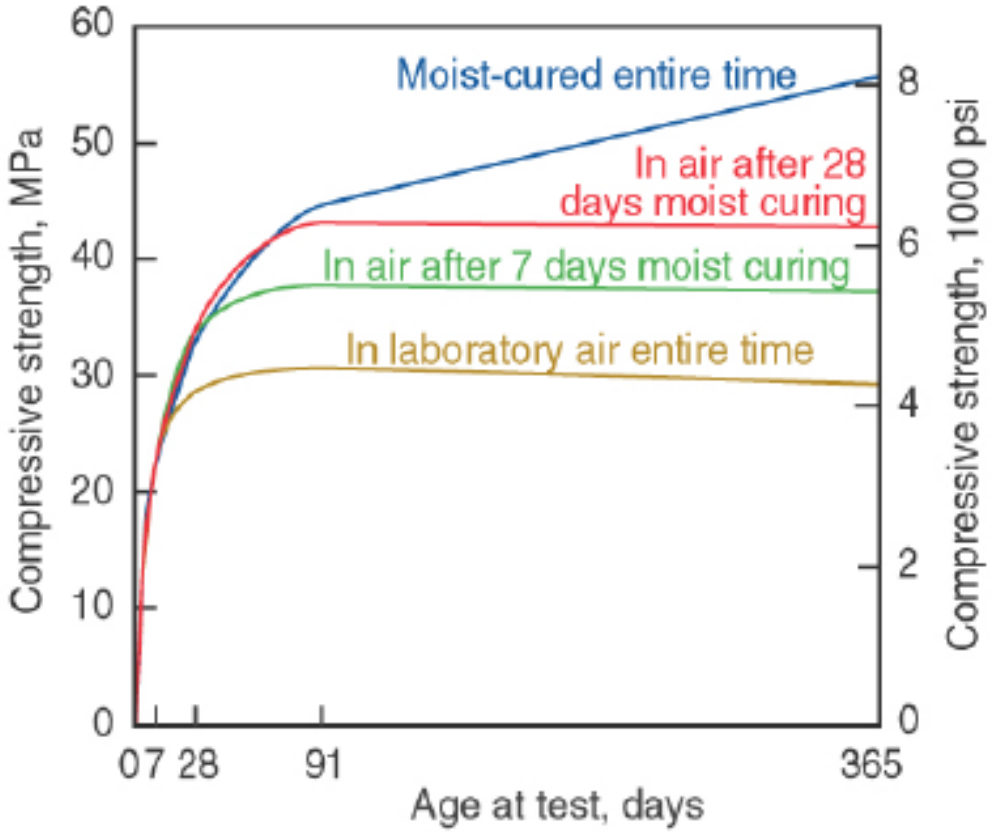
Inadequate



Effect on properties

- Strength
  - ~~Conventional wisdom~~
  - Not really





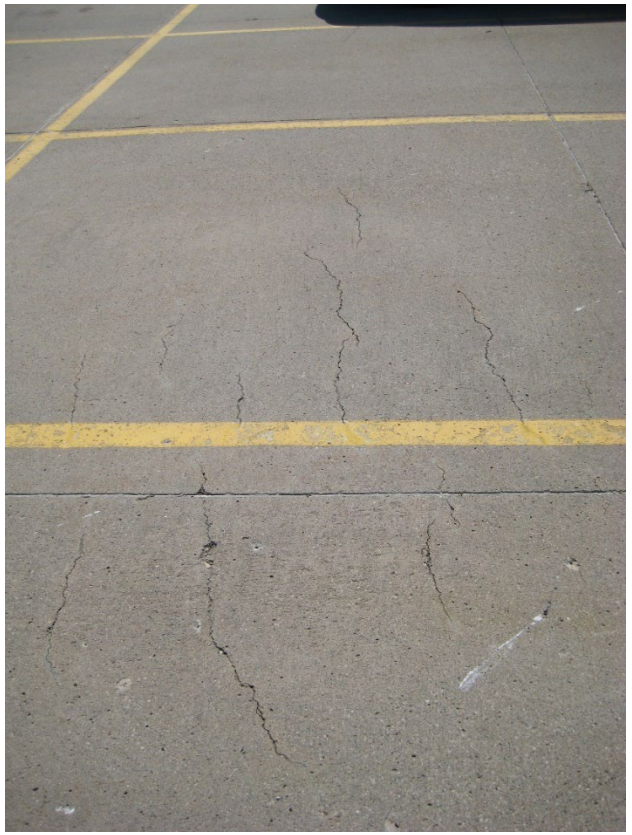
Effect on properties

- Permeability
  - Yes!!!
  - Because it is a surface effect

Water / cement ratio	Time
0.40	3 days
0.45	7 days
0.50	28 days
0.60	6 months
0.70	1 year
0.80	Never

Moisture Loss

- Plastic shrinkage (before set)
- Drying shrinkage (after set)

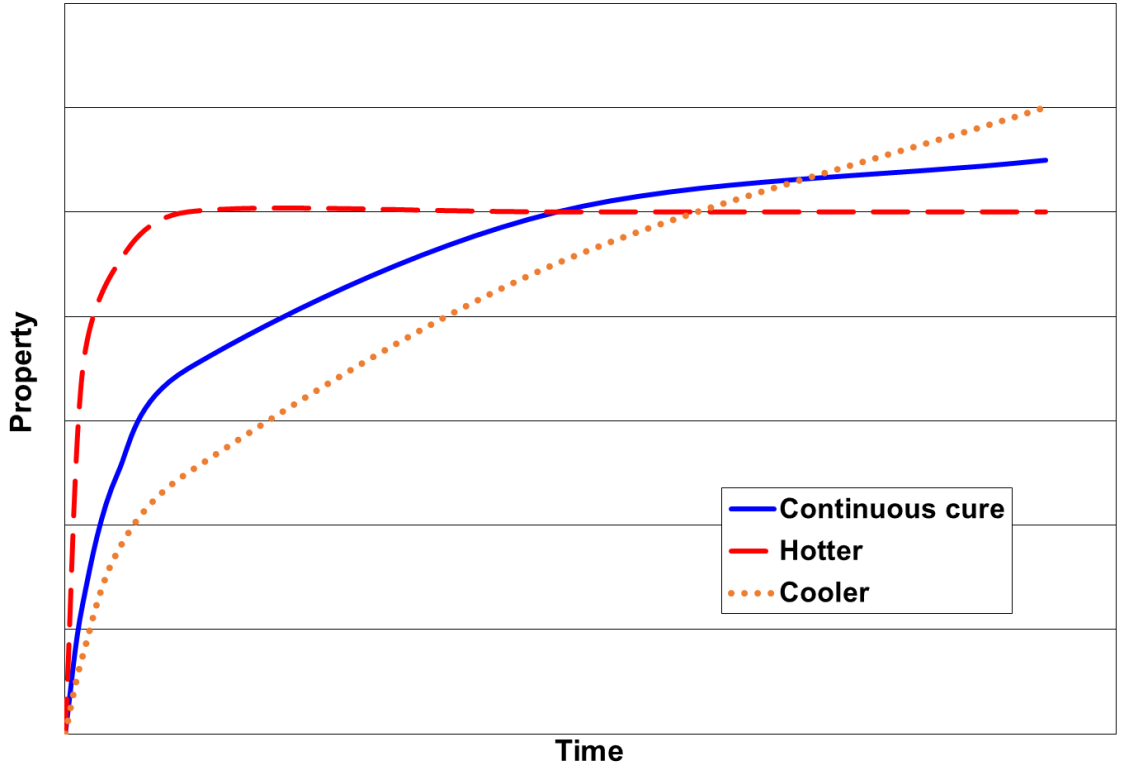


What About Temperature?

- Hydration halves with 18°F decrease in temperature
- But the drying may not be affected

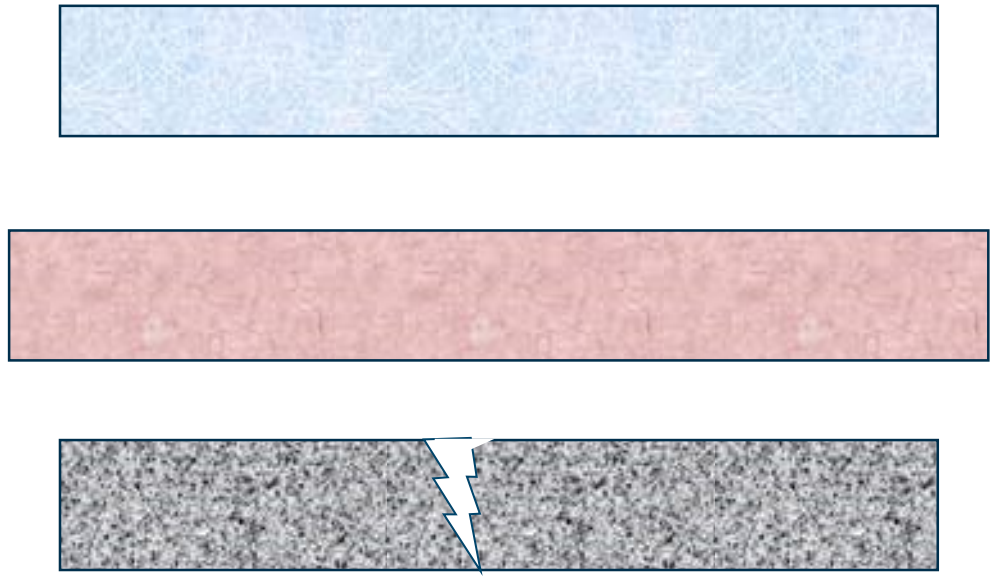
- We want to be like Goldilocks…
  - Not too hot
  - Not too cold

  - No shocks



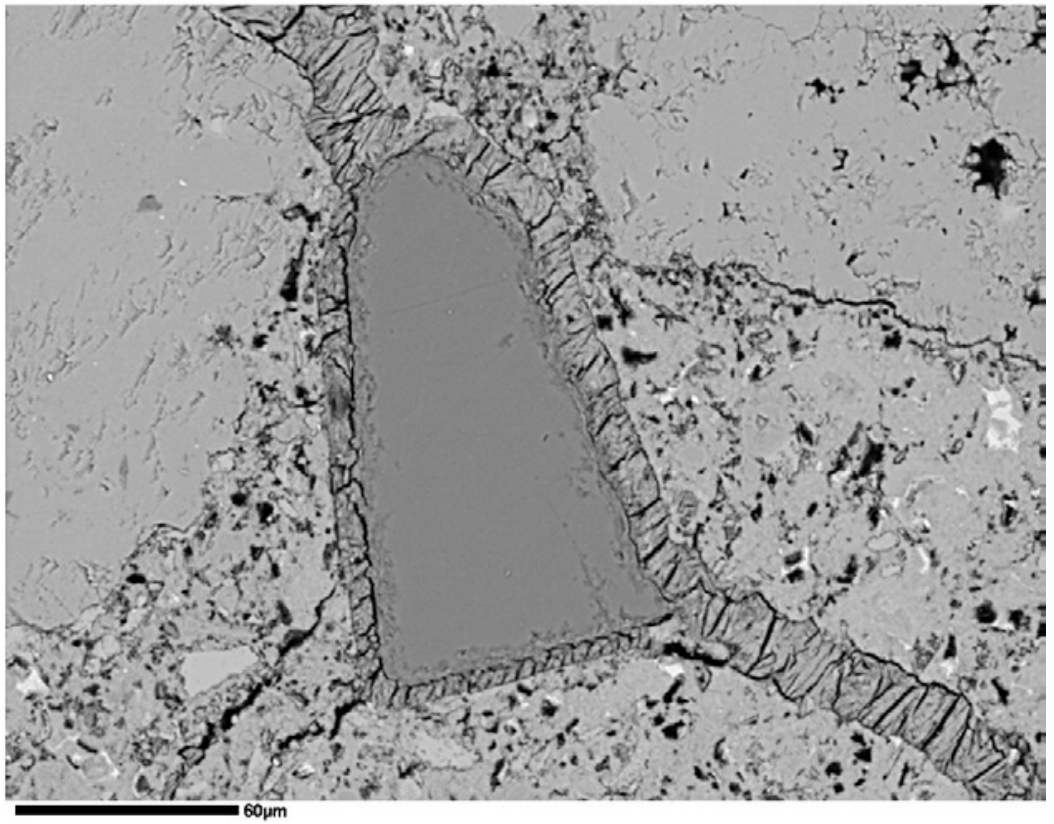
Thermal Shrinkage

- Concrete sets while hot and is expanded – then it shrinks
- Temperature peaks within the first 12 hours
- Air temperature often drops at the same
- Combined affect can be significant
- All while concrete is very weak
- Differentials >30°F will likely cause cracking



What is too hot?

- Delayed ettringite formation risk increases above ~160°F



Thomas et. al.

What is too cold?

- Hydration stops at about 14°F
- Freezing can occur in the pore solution
  - If mix is <500 psi

At the end of the day

- Wet enough for long enough to achieve desired hydration
- Uniformly enough to reduce drying stresses

- The right temperature to achieve desired hydration
- Avoiding temperature differentials

- Easy right?

Keep it wet
Keep it warm

Moisture control

- Prevent drying
- Add water from the outside
- Add water from within

Prevent drying

- Plastic sheets

Prevent drying

- Evaporation Retarder
  - Between placement and finishing
  - Reduces plastic shrinkage cracking
  - Not a finishing aid – beware of increasing surface w/cm

Prevent drying

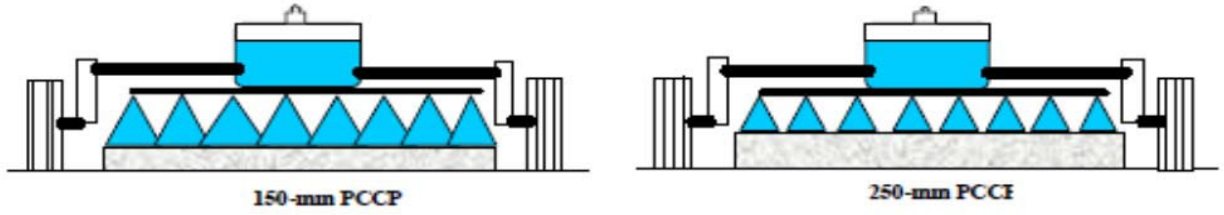
- Tent

Prevent drying

- Curing Compound
  - Poly-alpha-methylstyrene
  - ASTM C 309 or local requirements
  - White
  - Allow for effects of texture

Prevent Drying

- Use a machine
- Apply to moist surface
- Protect from wind
- Overlap
- Protect the compound from traffic



a.) Nozzle heights adjusted to obtain 30% overlap of adjacent spray patterns.

b.) Nozzles must be raised to retain 30% overlap for the 250-mm PCCP.

Add water from the outside

- Flood

Add water from the outside

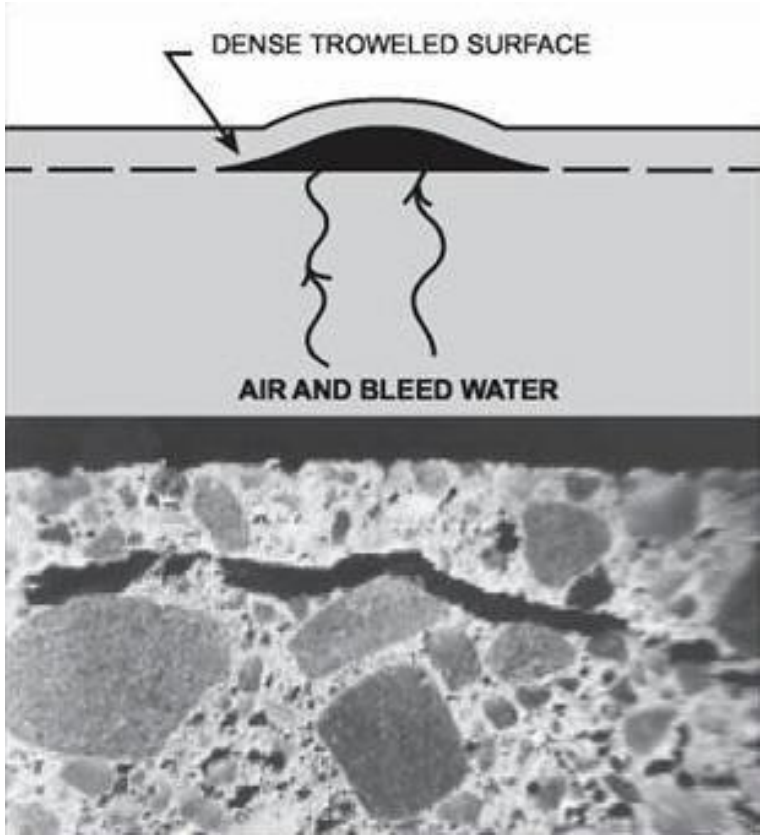
- Flood
- Burlap or absorbent materials

Add water from the outside

- Flood
- Burlap
- Fog

When

- Too early
  - Bleed water is trapped → flakey surface
  - Have to wait for texturing
- Too late
  - Why bother

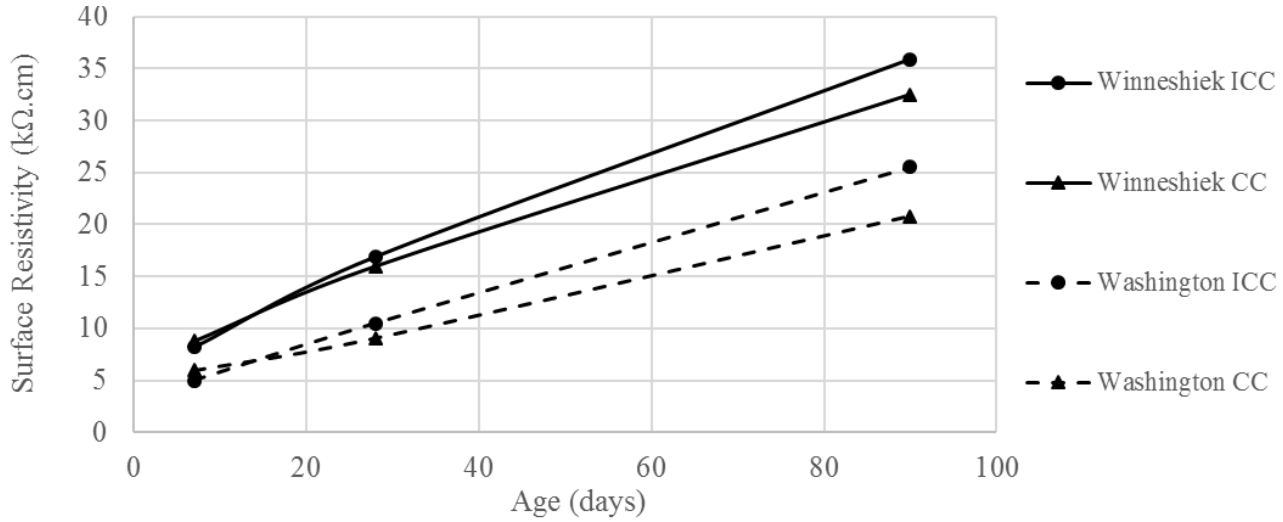


How Long?

- Until you have required properties at the surface
- When removing covers – avoid moisture and thermal shock

Internal Curing

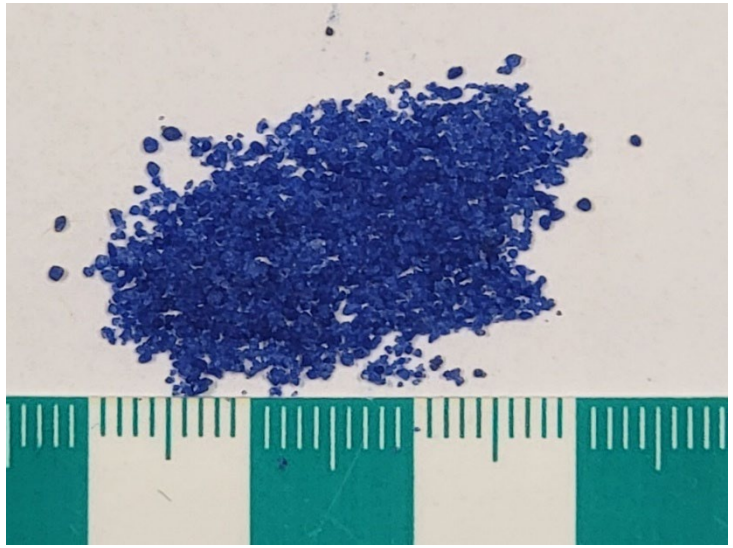
- Reported Benefits
  - Less shrinkage, cracking, curling
  - Better hydration & SCM reaction
    - Improved durability
    - Less cement
  - Extended service life
  - Increased sustainability

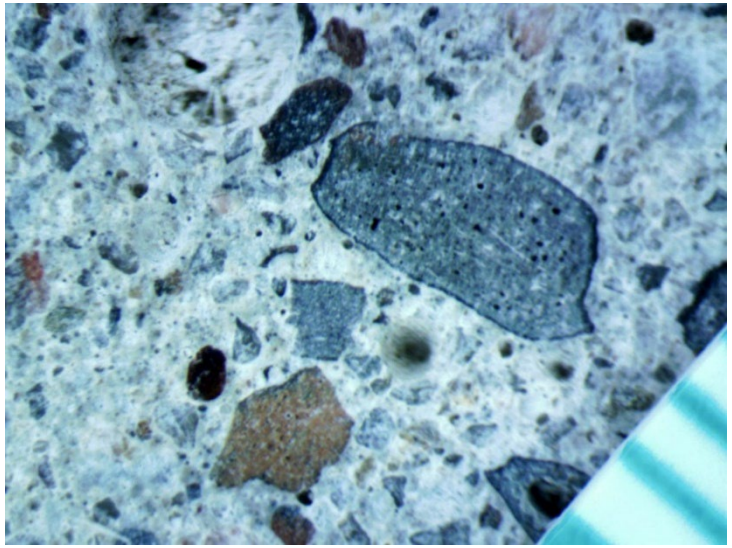


Internal Curing

- Expanded fine aggregate
- Super Absorbent Polymers

- About 7lb IC water for 100 lb cement



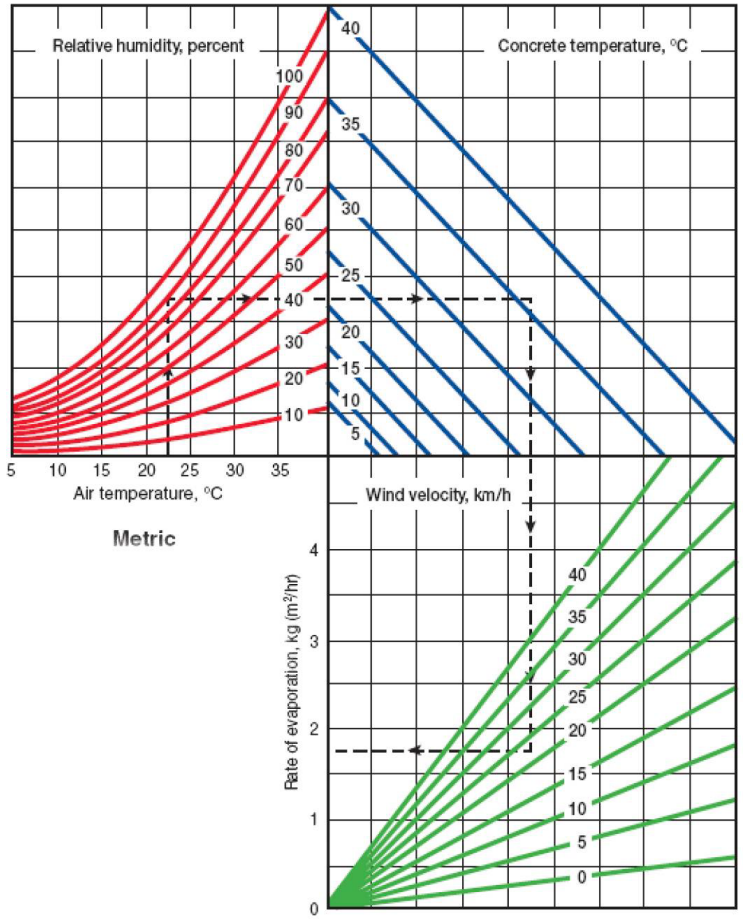


Internal Curing

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

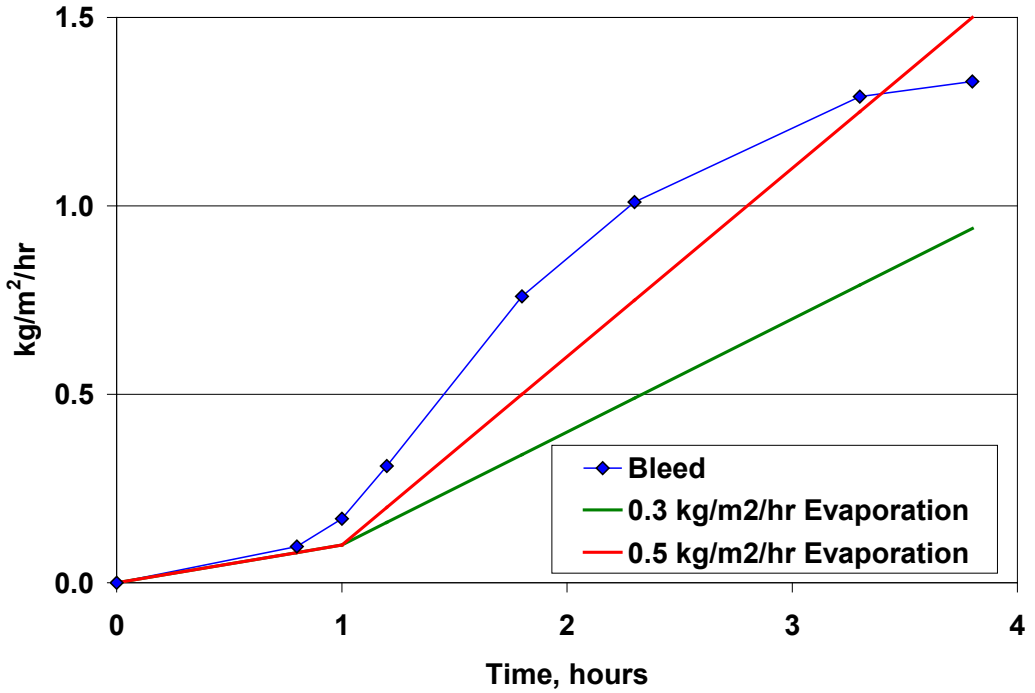
Temperature Control

- Hot Weather
  - Prevent evaporation



Temperature Control

- Hot Weather
  - Prevent evaporation
  - As a function of bleeding

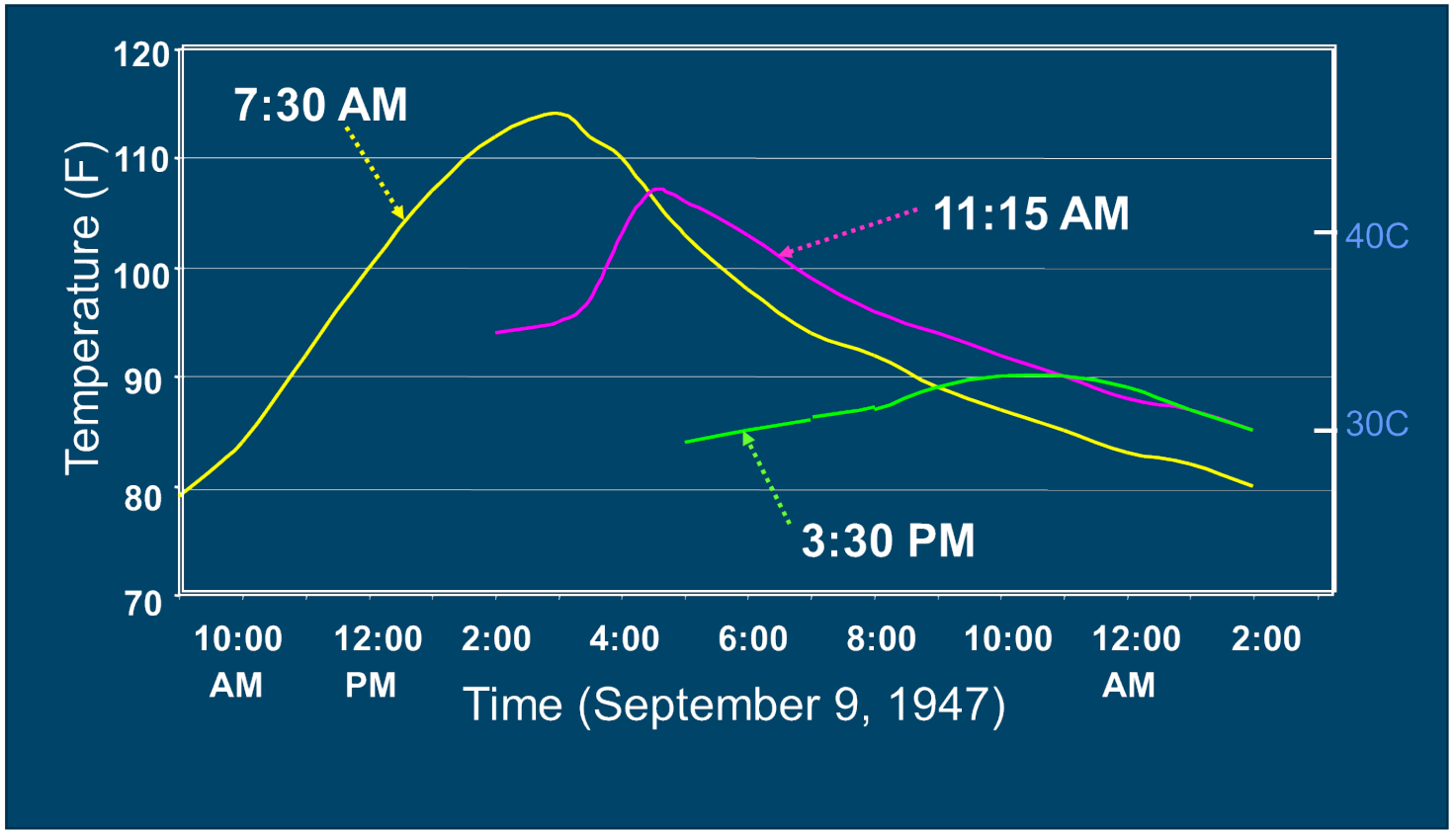


Temperature Control

- Hot Weather
  - Cool the mixture
    - Cold water
    - Shade stockpiles
    - Liquid nitrogen
    - Fog sprays
  - Hiperpav can model cracking risk

Temperature Control

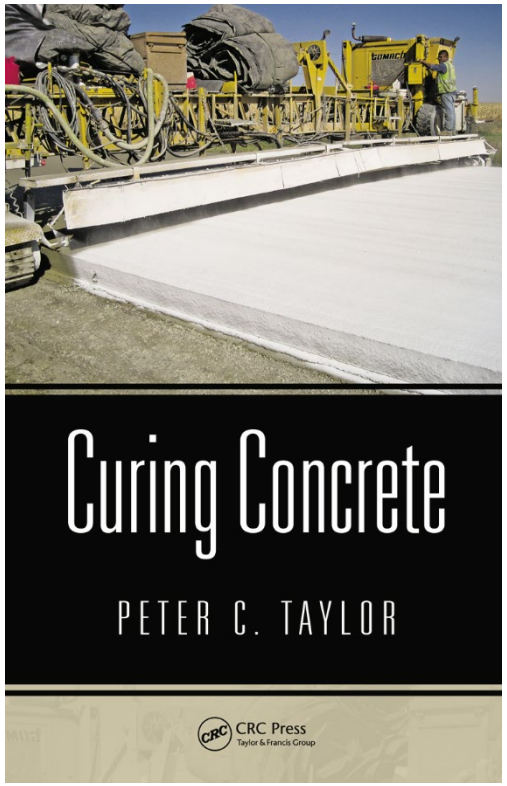
- Hot Weather
  - Consider placing at night



Temperature Control

- Cold Weather
  - Heat the support system
  - Remove frost
  - Keep it warm
    - Blankets
    - Hydronics
    - Heaters
- Beware of thermal gradients

Keep it wet
Keep it warm

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