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Architectural Concrete in Hot Weather

ACI Spring 2012 Convention
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Hot Weather Concrete

Specification Choices to achieve Architectural Concrete Results

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President
Texas Aggregates and Concrete Association

Dallas, Texas
March 21, 2012

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General Overview

- Battle of the Specification(s)
- First Principles
- Conflict Management

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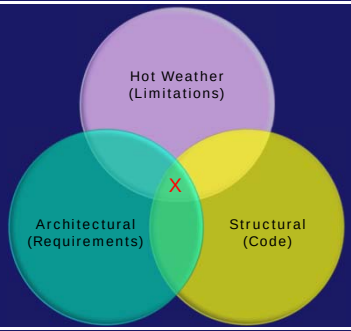
Let the Battle Begin!



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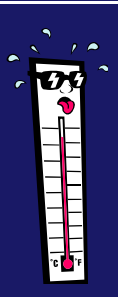
Hot Weather Specifications

- "Concrete shall not exceed 85^{0}F when arriving at job site."
- "Concrete shall not exceed 90^{0}F when arriving at job site."
- "Concrete shall not exceed 95^{0}F when arriving at job site."
- "Ice shall be used when concrete temperatures exceed 90^{0}F."



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Architectural Specifications

- "Architectural concrete shall maintain consistent color and hue."
- "In place concrete shall match color and shading of test panels."
- "No fly ash shall be used on architectural concrete."
- "Architectural concrete shall be consistent in color to the test panels as measured from 30ft away by a three person panel composed of the architect, the contractor, and the supplier."

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Structural Specifications

- "…w/cm shall not exceed 0.45"
- "Minimum 5.0 sack for all concrete."
- "Maximum slump of 4.0 in for all architectural concrete."
- "Air content shall be 5% on all exposed concrete."
- "Maximum of 20% fly ash replacement."

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First Principles: Cement Chemistry and Reactions

Structural Temperatures
Curing temperature (ambient conditions)
Core temperature (fixed conditions)
- Mix design and Element shape

HEAT

Chemically Driven
Cement content
w/cm ratio
Pozz. replacement

$C_3S + H \rightarrow CSH + CH$

The "BAD"

The "GOOD"
Set time
Initial strength <24hr
Final strength

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First Principles: Cement Chemistry and Reactions

Structural Temperatures
Curing temperature (increased?)
Core temperature (unchanged)
- Mix design (did not change)
- Element shape (did not change)

HEAT

$C_3S + H \rightarrow CSH + CH$

HEAT

The "GOOD"
Set time (decreased)
Initial strength (increased)
Final strength (unchanged?)

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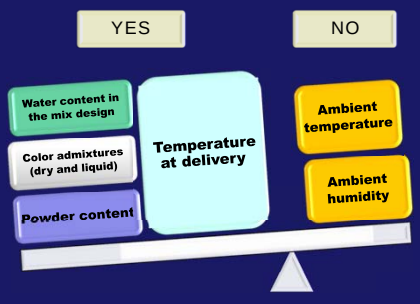
What do we actually control?



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Practical Construction Methods

- Mix Design
  - Lowest practical cement factor
  - Maximum practical aggregate
- Pozzolanic Materials
  - Maximum practical replacement
- Chemical
  - Set retarders, ASTM C494 Type D
  - Water reducers, ASTM C494 Type A
- Mechanical
  - Chilled water and/or ice
  - Evaporative cooling of aggregate

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Actual Impact on Production

Cement	489 lb
Fly ash	122 lb
w/cm	0.45
Water	275 lb
Ice (for 85 deg F)	100 lb

- At initial mixing w/cm = 0.29?!?
- Admixtures work from wetted cement grains
- What is actual mixing time?
- Inconsistent mixing equals
  - Inconsistent workability,
  - Inconsistent cement admixture interactions
  - Inconsistent slump
  - **Inconsistent color**

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Economics and Ownership

- Example:
  - 500 yd placement, 85 deg F temp. limitation
  - 700 lb, 20% replacement, 0.45 w/cm, 5000psi in 28 day
  - Owner spent +$6,000 on ice for each placement
  - Project will take +$360,000 in ice
- What direct benefits to the Owner?
  - Stronger concrete? Once the spec is met…
  - "Better" concrete?
  - Was the architectural design goal accomplished?

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Temperature Limits and Architectural Results

- Temperature of concrete is chemically driven
  - Mechanical process can impact the rate of chemical reaction, but will not determine the outcome.
  - Concrete core temperature is more important than delivery temperature.
- Temperature specifications exist as a measurement, not an indication of performance.
  - The concrete is not smart enough…

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Temperature Limits and Architectural Results

- Architectural success is a combination
  - Allowances are more important than restrictions, limitations, or prohibitions.
  - Let the materials work for you, not against you.
- Conditions can change rapidly, should decisions?
  - Have prior discussions about changes in ambient conditions
  - Have clear decision controls (actual people) available.

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Questions

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