BREAKING THE ICE
CONTROLLING SCC IN HOT WEATHER
ACI Salt Lake City March 2018 – EllisDon Construction Sciences
Stacia Van Zetten & Lloyd Keller

WHEN YOU HAVE TO COOL IT
WHY COOL CONCRETE?
TO CONTROL THE EXOTHERM AND TEMPERATURE DIFFERENTIALS.

ACI 301-16 “Specifications for Structural Concrete” and ACI 305.1-14 “Specification for Hot Weather Concreting” limit the maximum concrete temperature to 95 °F (35 °C) at the time of discharge.
ATRIO Tower Bogota, Colombia
OPTIONS FOR COOLING CONCRETE
1. Ice
1. Ice

2. Liquid Nitrogen
1. Ice
2. Liquid Nitrogen
3. Cooling Materials


Remya, R., and Shaha, R., 1984, "Shrinkage of Fresh Mortar Cast under and exposed to Hot Dry Climatic Conditions," *Proceedings, Colloquium on Strainage of Hydraulic Concrete, KILEMColumbus, Ohio, V. 2*, Institute of Brazilian Construction, MACK.


APPENDIX A—ESTIMATING CONCRETE TEMPERATURE

A1—Estimating temperature of freshly mixed concrete

Equation for estimating temperature T of freshly mixed concrete are shown in Eq. (A-1) through (A-5).

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w} \]  

(A-1)

With ice (in °C):

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 112.5}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 112.5} \]  

(A-2)

Without ice (in °C):

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6} \]  

(A-3)

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6} \]  

(A-4)

With ice (in °C):

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w} \]  

(A-5)

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6} \]  

(A-5)

\[ T = \frac{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6}{0.22(T_w - T_a) + T_w - T_w + T_w - T_w + 79.6} \]  

(A-5)
CHALLENGES WITH ICE
1. Ice Shape/Geometry

- Cube
- Flake
- Sheet
- Tube
Slump at plant and slump at site with flake ice

- Slump at Plant
- Slump at Site

Linear (Slump at Plant)
Linear (Slump at Site)
Slump at plant and slump at site with cube ice

Slump at Plant

Slump at Site

Linear (Slump at Plant)

Linear (Slump at Site)

$y = 8.4647x + 69.097$

$y = 9.9008x + 63.073$
1. Ice Shape/Geometry
2. Ice Addition Methods
1. Ice Shape/Geometry
2. Addition Methods
1. Ice Shape/Geometry
2. Addition Methods
3. Traffic Considerations
Se realizó un estudio de la velocidad promedio por hora y por día para determinar los tiempos de ciclo desde cada una de las plantas hacia el proyecto, se hallaron tiempos de transito máximos desde Planta Sur al proyecto de 84 minutos en las horas pico.

| Día       | 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total general |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----------------|
| Domingo   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |
| CO-PLANTA FONTIBÓN | 34,4 | 34,4 | 34,4 | 33,3 | 33,3 | 49,5 | 44,8 | 44,8 | 56,6 | 56,6 | 60,5 | 53,2 | 53,2 | 46,5 | 47,9 | 51,8 |    | 45,3          |
| CO-PLANTA PUENTE ARANDA | 36,4 | 36,4 | 36,4 | 36,4 | 33,6 | 33,6 | 49,0 | 49,0 | 56,0 | 56,0 | 60,6 | 63,0 | 60,6 | 56,0 | 49,0 | 56,0 | 56,0 |    | 47,7          |
| CO-PLANTA PUENTE ARANDA L2 | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 28,0 | 28,0 | 36,4 | 36,4 | 39,2 | 39,2 | 39,2 | 39,2 | 39,2 | 39,2 | 39,2 | 28,0 | 25,2 | 25,2 | 28,0 |
| CO-PLANTA SIBERIA | 42,0 | 42,0 | 42,0 | 42,0 | 39,2 | 39,2 | 56,0 | 56,0 | 56,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 |
| CO-PLANTA SUR (DTE) | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 63,0 | 63,0 | 77,0 | 77,0 | 84,0 | 84,0 | 84,0 | 63,0 | 63,0 | 70,0 |    |    |               |
| Viernes   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |
| CO-PLANTA FONTIBÓN | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 |
| CO-PLANTA PUENTE ARANDA | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 28,0 | 25,2 | 25,2 |
| CO-PLANTA PUENTE ARANDA L2 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 28,0 | 25,2 | 25,2 | 28,0 |
| CO-PLANTA SIBERIA | 77,0 | 77,0 | 84,0 | 84,0 | 77,0 | 77,0 | 63,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 56,0 | 72,3 |    |    |
| CO-PLANTA SUR (DTE) | 70,0 | 70,0 | 70,0 | 73,0 | 73,0 | 73,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 |
| Sábado    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |
| CO-PLANTA FONTIBÓN | 36,4 | 36,4 | 36,4 | 36,4 | 36,4 | 36,4 | 56,0 | 56,0 | 56,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 | 63,0 |
| CO-PLANTA PUENTE ARANDA | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 28,0 | 28,0 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 28,0 | 22,4 |
| CO-PLANTA PUENTE ARANDA L2 | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 22,4 | 28,0 | 28,0 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 30,8 | 28,0 | 22,4 |
| CO-PLANTA SIBERIA | 42,0 | 42,0 | 42,0 | 42,0 | 42,0 | 42,0 | 70,0 | 70,0 | 77,0 | 77,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 | 84,0 |
| CO-PLANTA SUR (DTE) | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 49,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 | 77,0 |

**Light Traffic**: [Highlighted Row]

**Heavy Traffic**: [Highlighted Row]
Ice Consumption

![Graph showing ice consumption and temperature data.]

- **Ice Consumption**
  - Time: 3:00:00 to 5:00:00
  - Ice: 50 to 120 Kg
  - Dates: 18/05/2017, 8/06/2017, 19/07/2017, 23/08/2017

- **Temperature**
  - Min (°C): 15 to 25
  - Max (°C): 10 to 20
  - Dates: 18/05/2017, 8/06/2017, 19/07/2017, 23/08/2017
1. Ice Shape/Geometry

2. Addition Methods

3. Traffic Considerations

4. Material Variations
5.2.2.6 Mixing water
Mixing water shall consist of all water in the batch, including water occurring as surface moisture on the aggregate, water contained in admixture solutions, wash water, slurry water and ice used as a concrete coolant. Ice shall be measured by mass. Added liquid water may be measured by mass or volume, as permitted in Clause 5.2.3.3.

**Note:** Variations in aggregate moisture content, especially of the finer materials, can be significant. Frequent checks, followed by any required adjustments to the batch quantities of aggregate and water, are necessary for achieving good quality control.
METHODS AND MEASUREMENTS TO CONTROL PROPERTIES
Plastic Properties

1. Time between batching and placing (Max 2.5 hours with Hydration Stabilizer)
2. Slump Flow (ASTM C1611) 60 – 70 cm
3. T50 (ASTM C1611) 2 – 5 seconds
4. VSI (ASTM C1611) 0 – 1
5. Temperature at placing (Maximum 22 deg C)
6. Air Content (Maximum 4%)
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SUMMARY
WHAT WE LEARNED

• The shape of the ice can affect the consistency of the fresh concrete
• Control the way you add the ice
• Cool your materials by chilling water or shading aggregate
• Maximize stockpile size and moisture uniformity
• Pre planning early pours to avoid traffic and ambient temperature increase
• Monitor the fresh properties
Questions?