WHEN YOU HAVE TO COOL IT

BREAKING THE ICE

CONTROLLING SCC IN HOT WEATHER

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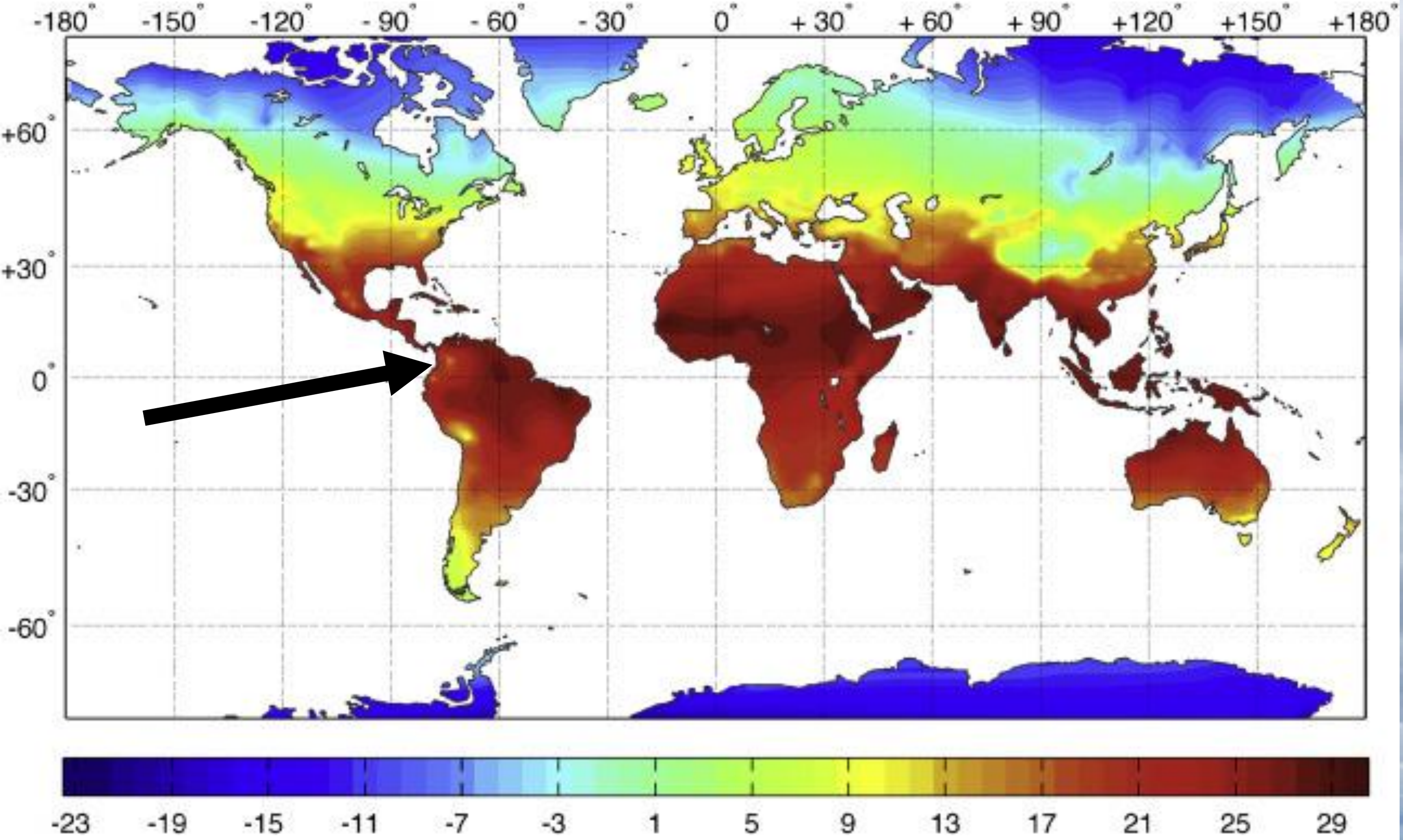
WHY COOL CONCRETE?

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 ºC)** at the time of discharge.

ATRIO Tower Bogota, Colombia



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°C	14	13	15	15	15	14	14	14	14	14	14	12
°F	57	55	59	59	59	57	57	57	57	57	57	54

OPTIONS FOR COOLING CONCRETE

1. Ice

1. Ice

2. Liquid Nitrogen

1. Ice

2. Liquid Nitrogen

3. Cooling Materials

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APPENDIX A—ESTIMATING CONCRETE TEMPERATURE

A1—Estimating temperature of freshly mixed concrete

Equations for estimating temperature T of freshly mixed concrete are shown in Eq. (A-1) through (A-3).

Without ice (in.-lb and SI units)

$$T = \frac{0.22(T_aW_a + T_cW_c) + T_wW_w + T_aW_{wa}}{0.22(W_a + W_c) + W_w + W_{wa}} \quad \text{(A-1)}$$

With ice (in.-lb units)

$$T = \frac{0.22(T_aW_a + T_cW_c) + T_wW_w + T_aW_{wa} - 112W_i}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} \quad \text{(A-2)}$$

With ice (SI units)

$$T = \frac{0.22(T_aW_a + T_cW_c) + T_wW_w + T_aW_{wa} - 79.6W_i}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} \quad \text{(A-3)}$$

where

T_a = temperature of aggregate;
T_c = temperature of cement;
T_w = temperature of batched mixing water from normal supply excluding ice;
T_i = temperature of ice, °F (°C) (Note: Temperature of free and absorbed water on the aggregate is assumed to be the same temperature as the aggregate.);
W_a = dry mass of aggregate;
W_c = mass of cement;
W_i = mass of ice;
W_w = mass of batched mixing water; and
W_{wa} = mass of free and absorbed moisture in aggregate at T_a, lb (kg).

A2—Estimating temperature of concrete with ice

Equations (A-2) and (A-3), for estimating the temperature of concrete with ice in U.S. customary or SI units, assume that the ice is at its melting point. A more exact approach would be to use Eq. (A-4) or (A-5), which includes the temperature of the ice.

With ice (in.-lb units)

$$T = \frac{0.22(T_aW_a + T_cW_c) + T_wW_w + T_aW_{wa}}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} + \frac{T_aW_{wa} - W_i(128 - 0.5T_i)}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} \quad \text{(A-4)}$$

With ice (SI units)

$$T = \frac{0.22(T_aW_a + T_cW_c) + T_wW_w + T_aW_{wa}}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} + \frac{T_aW_{wa} - W_i(79.6 - 0.5T_i)}{0.22(W_a + W_c) + W_w + W_i + W_{wa}} \quad \text{(A-5)}$$

E-560-3-A-28-65-1-3-653

Material	Weight (kg)	Density (kg/L)	Volume (l/m3)
Caracolito	436	3,12	140
Fly ash	109	2,13	51
Water	174	1,00	174
Sand - Agregados Nacionales	773	2,62	295
Gravel 1/2" - Cachibi	904	2,91	311
Air	1,50%		15,0
Isoflow 8800	4,09	1,09	3,75
Isoretard 212	3,27	1,06	3,08
Isostab 6003	1,64	1,00	1,64
Isokhore 2500	8,18	1,00	8,18

CONSTRUCTION SCIENCES

CHALLENGES WITH ICE

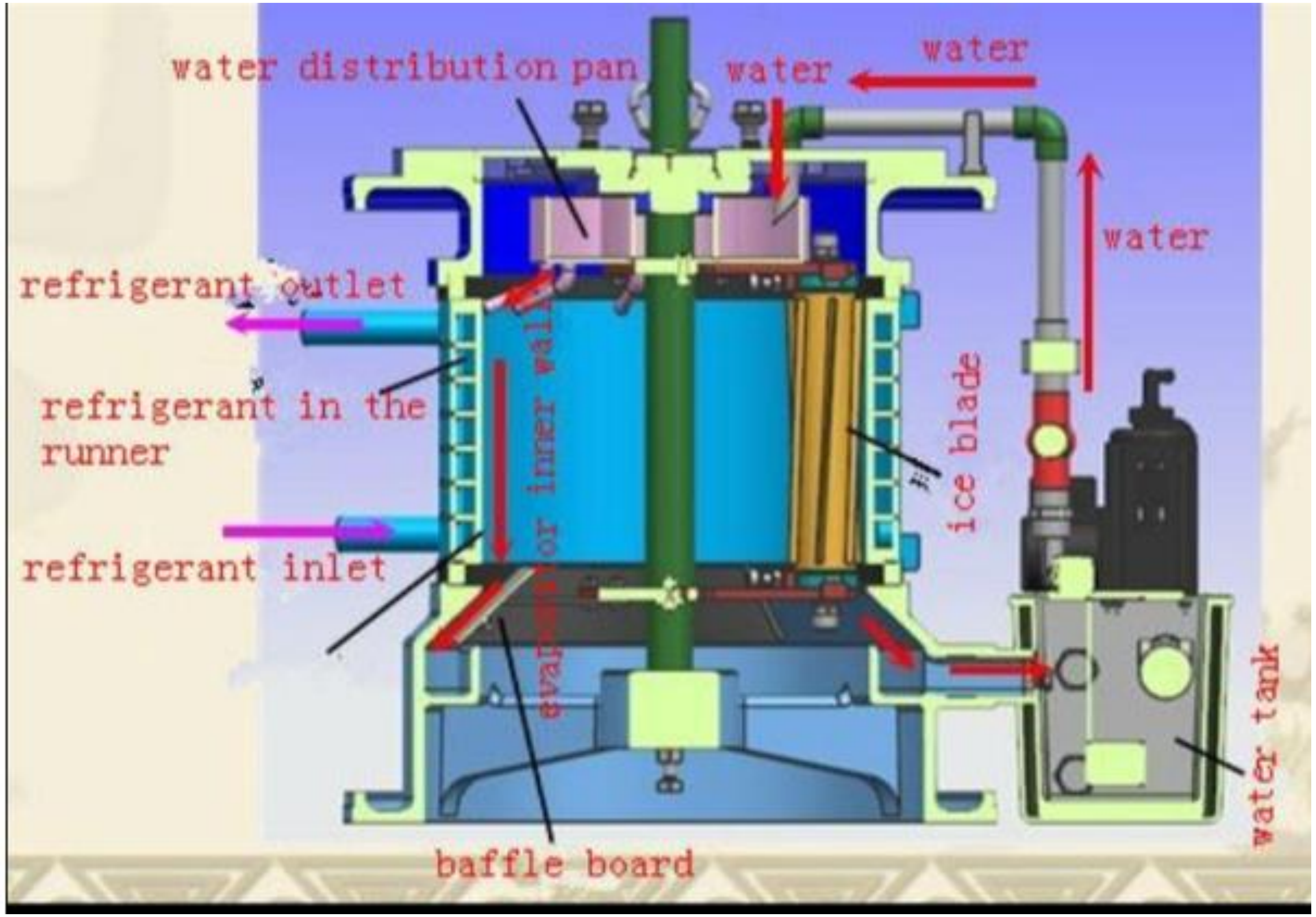
1. Ice Shape/Geometry

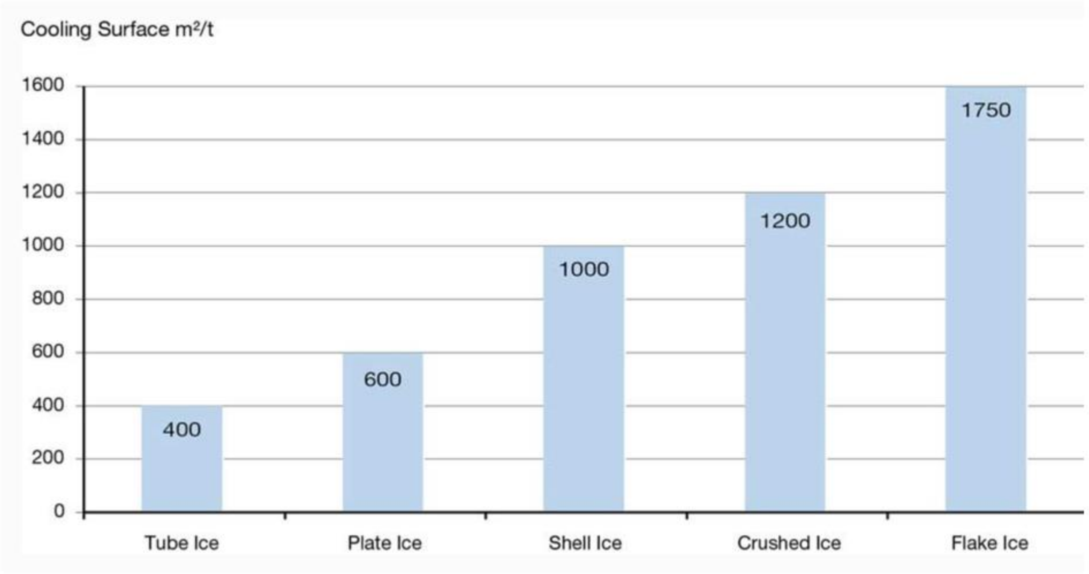
Cube

Flake

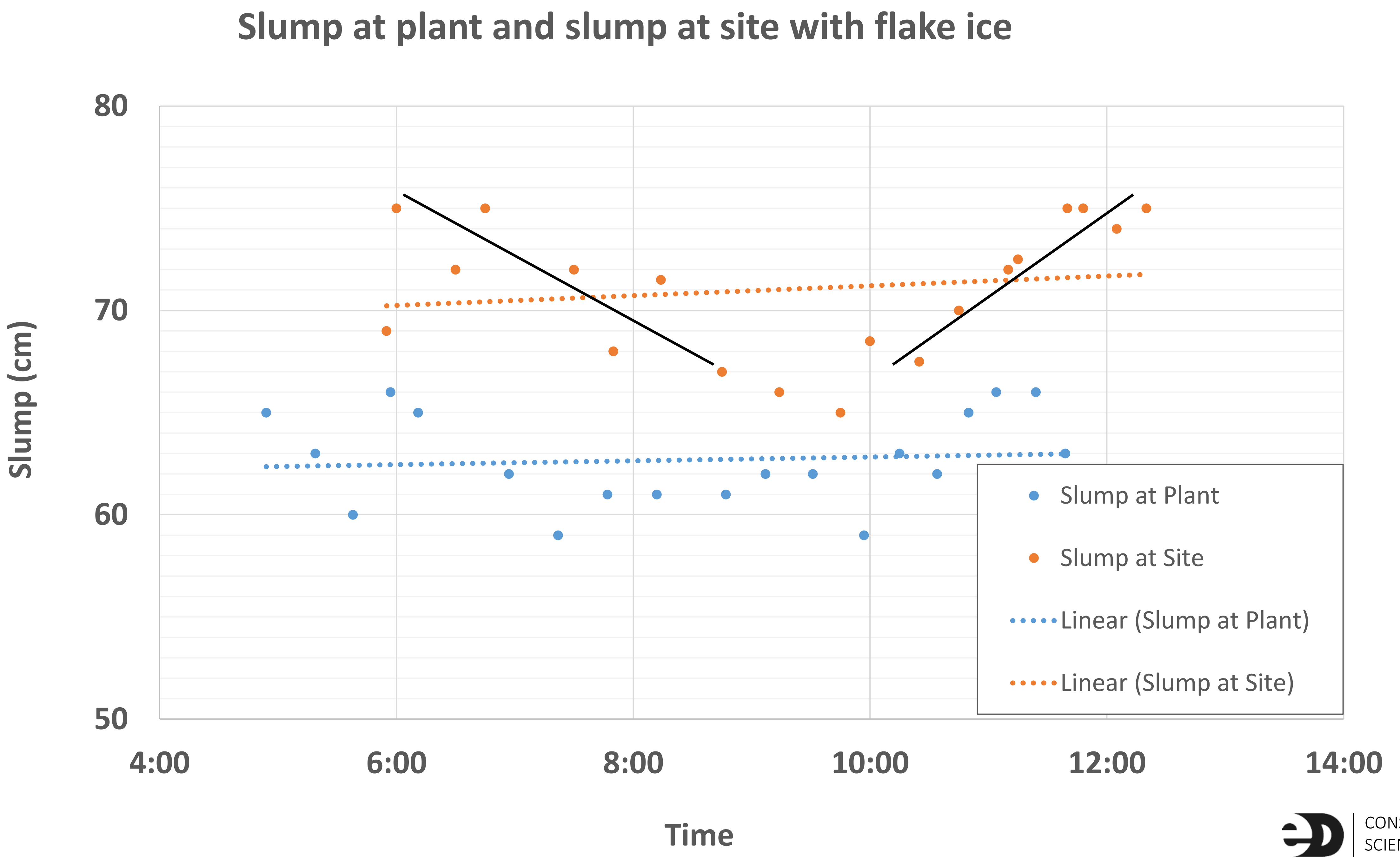
Sheet

Tube



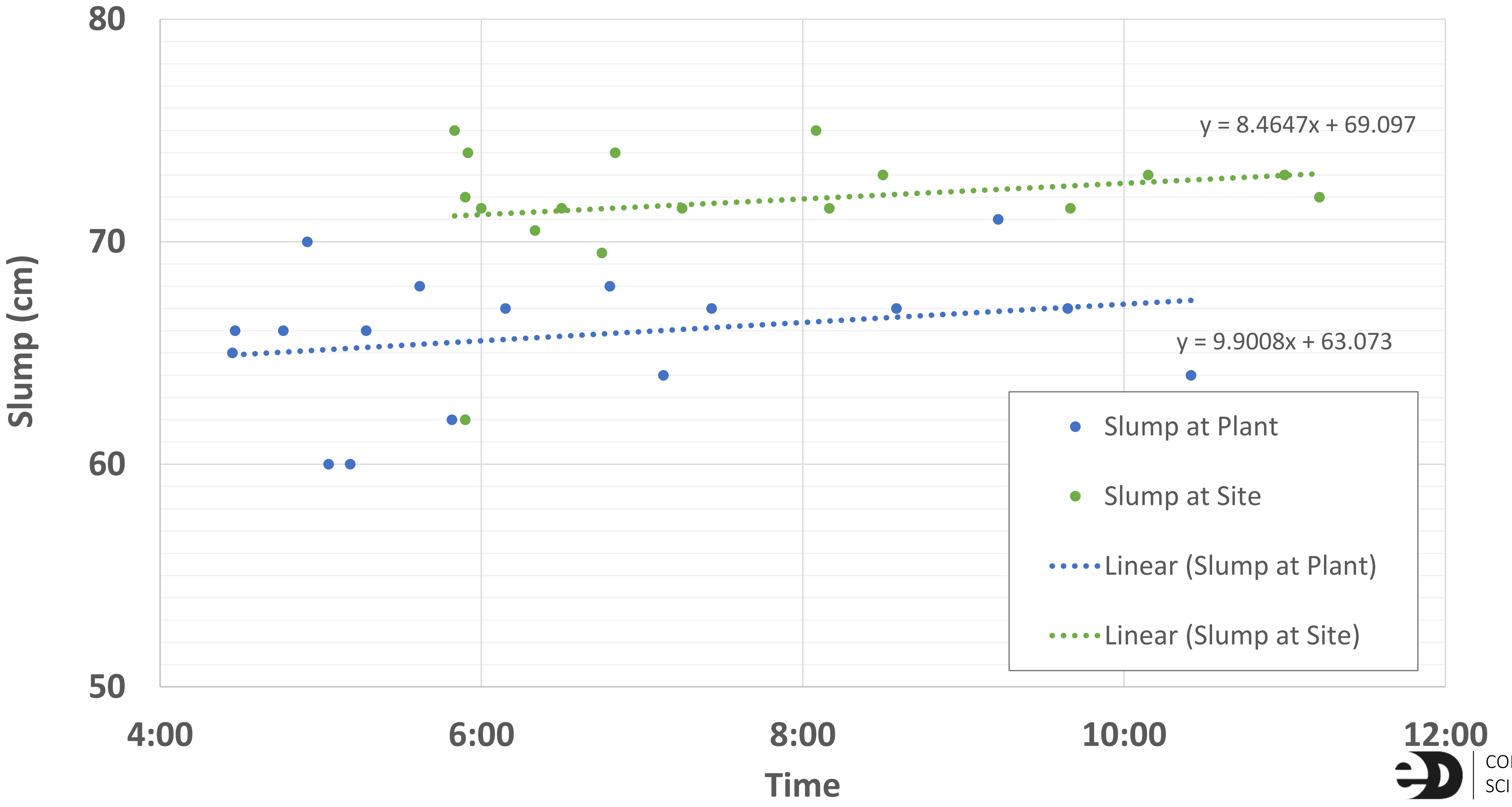


Benefits of Flake Ice



CONSTRUCTION SCIENCES

Slump at plant and slump at site with cube ice



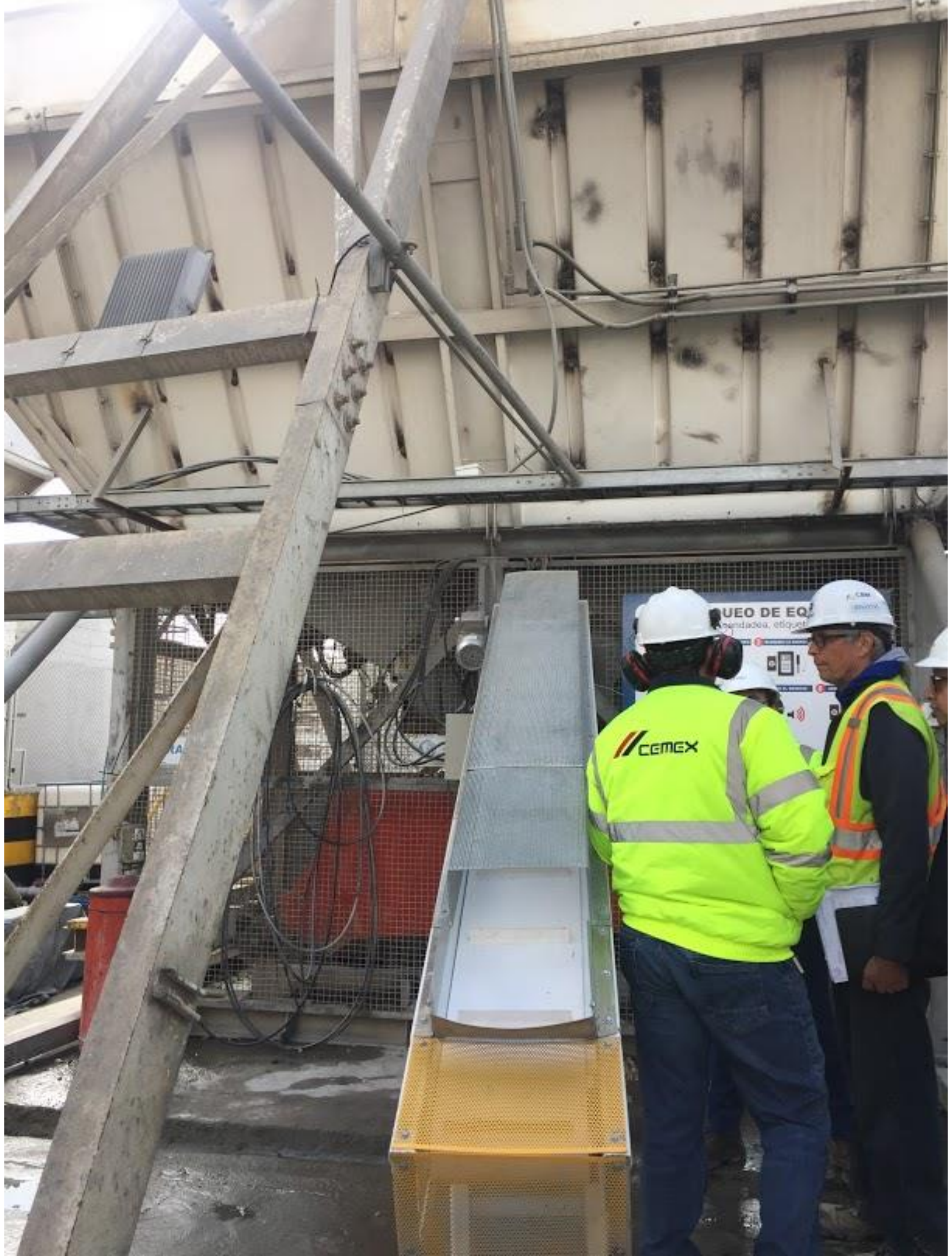
CONSTRUCTION SCIENCES

1. Ice Shape/Geometry

2. Ice Addition Methods


MEX


DIESEL



CONSTRUCTION SCIENCES

1. Ice Shape/Geometry
2. Addition Methods
3. Traffic Considerations

Plantas

Estudio de Tiempos por horas y por días desde las plantas al proyecto

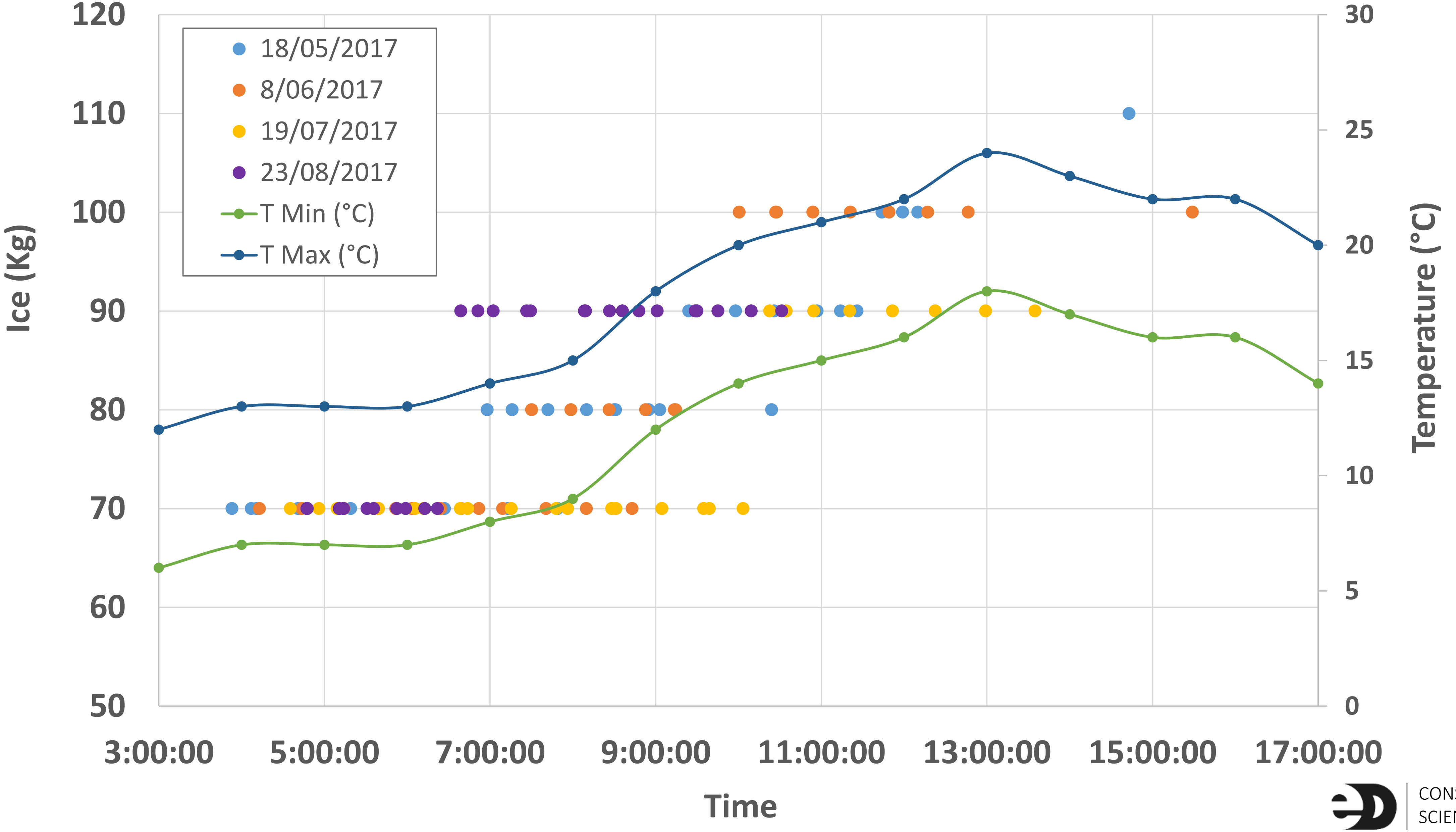
Se realizo un estudio de la velocidad promedio por hora y por día para determinar los tiempos de ciclo desde cada una de las plantas hacia el proyecto, se hallaron tiempos de transito máximos desde Planta Sur al proyecto de 84 minutos en las horas pico.

Light Traffic

Heavy Traffic

_Tiempo Transito [Min]	Hora																								
Dia	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total general
Domingo	**34,4**	**34,4**	**34,4**	**34,4**	**33,3**	**33,3**	**39,5**	**44,8**	**44,8**	**44,8**	**56,6**	**56,6**	**56,6**	**60,5**	**53,2**	**53,2**	**46,5**	**47,9**	**51,8**						**45,3**
CO-PLANTA FONTIBÒN	36,4	36,4	36,4	36,4	33,6	33,6	42,0	49,0	49,0	49,0	56,0	56,0	56,0	63,0	56,0	56,0	49,0	56,0	56,0						47,7
CO-PLANTA PUENTE ARANDA	22,4	22,4	22,4	22,4	22,4	22,4	25,2	28,0	28,0	28,0	36,4	36,4	36,4	39,2	28,0	28,0	25,2	25,2	28,0						27,7
CO-PLANTA PUENTE ARANDA L2	22,4	22,4	22,4	22,4	22,4	22,4	25,2	28,0	28,0	28,0	36,4	36,4	36,4	39,2	28,0	28,0	25,2	25,2	28,0						27,7
CO-PLANTA SIBERIA	42,0	42,0	42,0	42,0	39,2	39,2	49,0	56,0	56,0	56,0	77,0	77,0	77,0	77,0	70,0	70,0	70,0	70,0	77,0						59,4
CO-PLANTA SUR (DTE)	49,0	49,0	49,0	49,0	49,0	49,0	56,0	63,0	63,0	63,0	77,0	77,0	77,0	84,0	84,0	84,0	63,0	63,0	70,0						64,1
Viernes																**54,3**	**54,3**	**55,7**	**54,3**	**52,9**	**52,9**	**44,8**	**42,3**	**40,9**	**50,3**
CO-PLANTA FONTIBÒN																63,0	63,0	63,0	63,0	63,0	63,0	49,0	49,0	42,0	57,6
CO-PLANTA PUENTE ARANDA																30,8	30,8	30,8	30,8	30,8	30,8	28,0	25,2	25,2	29,2
CO-PLANTA PUENTE ARANDA L2																30,8	30,8	30,8	30,8	30,8	30,8	28,0	25,2	25,2	29,2
CO-PLANTA SIBERIA																77,0	77,0	84,0	84,0	77,0	77,0	63,0	56,0	56,0	72,3
CO-PLANTA SUR (DTE)																70,0	70,0	70,0	63,0	63,0	63,0	56,0	56,0	56,0	63,0
Sábado	**34,4**	**34,4**	**34,4**	**34,4**	**34,4**	**34,4**	**43,7**	**50,7**	**53,2**	**53,2**	**54,6**	**58,5**	**58,5**	**57,4**	**55,7**	**55,7**	**50,1**	**49,0**	**51,5**	**51,5**	**47,6**	**46,2**	**46,2**	**34,4**	**46,9**
CO-PLANTA FONTIBON	36,4	36,4	36,4	36,4	36,4	36,4	49,0	56,0	56,0	56,0	56,0	63,0	63,0	70,0	63,0	63,0	56,0	56,0	56,0	56,0	56,0	49,0	49,0	36,4	51,2
CO-PLANTA PUENTE ARANDA	22,4	22,4	22,4	22,4	22,4	22,4	25,2	25,2	28,0	28,0	28,0	30,8	30,8	28,0	30,8	30,8	30,8	28,0	30,8	30,8	28,0	28,0	28,0	22,4	27,0
CO-PLANTA PUENTE ARANDA L2	22,4	22,4	22,4	22,4	22,4	22,4	25,2	25,2	28,0	28,0	28,0	30,8	30,8	28,0	30,8	30,8	30,8	28,0	30,8	30,8	28,0	28,0	28,0	22,4	27,0
CO-PLANTA SIBERIA	42,0	42,0	42,0	42,0	42,0	42,0	56,0	70,0	77,0	77,0	84,0	84,0	84,0	84,0	84,0	84,0	70,0	70,0	70,0	70,0	63,0	63,0	63,0	42,0	64,5
CO-PLANTA SUR (DTE)	49,0	49,0	49,0	49,0	49,0	49,0	63,0	77,0	77,0	77,0	77,0	84,0	84,0	77,0	70,0	70,0	63,0	63,0	70,0	70,0	63,0	63,0	63,0	49,0	64,8
Total general	**34,4**	**34,4**	**34,4**	**34,4**	**33,9**	**33,9**	**41,6**	**47,7**	**49,0**	**49,0**	**55,6**	**57,5**	**57,5**	**58,9**	**54,5**	**54,4**	**50,3**	**50,9**	**52,5**	**52,2**	**50,3**	**45,5**	**44,2**	**37,7**	**46,9**

Ice Consumption



CONSTRUCTION SCIENCES

1. Ice Shape/Geometry
2. Addition Methods
3. Traffic Considerations
4. Material Variations


ARENA
GRUESA
AA1
ARENA

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%)

FECHA

Slump at Plant

Slump at Site

VIAJE	PLANTA	REMISION	CODIGO CAMION	M3	M3/ACUM	ASENT PLANTA	HORA CARGUE	HORA SAL PLANTA	HORA LLEG OBRA	HORA FIN DESC	ASENT. OBRA	TEMP (GRADOS)	OBSERVACIONES
1	P. Aranda	104757574	1493	7	7	55	5:45	6:15	6:40	8:00	65	22	T 3.40
2	P. Aranda	104776341	1307	7	14	65	6:03	6:55	7:15	7:45	65	19	T 2.19
3	Fontibon	104757482	1603	7		64	6:00	6:40	7:30		30-78	18	T 3.23 Devuelto
4	P. Aranda	[illegible]	1693	7	21	57	6:35	7:00	7:45	8:24	69	19	T 3.22
5	Fontibon	104757493	1716	7	28	63	5:32	6:50	7:50	8:25	60.5	18	T 4.45 Isoflow 0.5
6	P. Aranda	104777449	1494	7		56	6:56	7:40	8:05		35-74	19	T 1.9 Devuelto
7	P. Aranda	104777600	1605	7		65	7:06	7:45	8:10		74-78	19	T 3.13 Devuelto
8	Fontibon	104777335	1444	7	35	53	6:56	7:40	8:15	9:10	73-72	19	T 3.24
9	P. Aranda	104770056	1667	7	42	60	7:35	8:05	8:37	9:18	66.5	21	T 5
10	P. Aranda	104779621	3447	7	49	53	8:07	8:53	9:13	9:35	64	20	T 2.74
11	Fontibon	104777601	1709	7	56	55	8:27	9:00	9:43	10:18	60-63	20	T 5.33, Isoflow 0.5
12	Fontibon	104777829	1704	7	63	58	8:18	9:10	10:00	10:52	66-68	21	T, 6.47. T 5.19 T 3.9, 0.5 Isoflow
13	Fontibon	104778065	1669	7		65	7:50	9:15	10:12		43-47	20	1.6 L Isoflow - 53 cm, se devuelve
14	Fontibon	104778459	1720	5	69	49	9:22	10:10	10:46	11:15	67	21	T 4.47
15	P. Aranda	104778480	1693	7	76	52	9:29	10:25	11:00	12:10	52-61	24	T 2. 1 L. Isoflow
16	P. Aranda	104780042	1713	7	83	52	10:29	10:50	11:20	11:50	61	24	T 2.79 0.5 L. Isoflow
17	Fontibon	104785140	1716	7	90	58	10:28	11:00	11:45	12:15	59-71	22	T 3, 1 L. Isoflow
18	P. Aranda	104779014	1494	7	97	56	12:59	13:40	14:10	14:54	47-62	26	T 3.59, 1 litro Isoflow
19	P. Aranda	104779939	1302	7	104	65	13:13	14:00	14:28	15:15	55-60	24	T 3.72, 1 L. Isoflow
20													

SUPERVISÓ EN OBRA

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?
CONSTRUCTION
SCIENCES