PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA

ESTUDIO TERMODINÁMICO TEÓRICO - PRÁCTICO SOBRE EL COMPORTAMIENTO DE VACIADOS DE CONCRETO MASIVO A MÁS DE 4 700 m.s.n.m EN LA SIERRA DEL PERÚ

ANEXOS

Lima, mayo del 2015

ANEXO A: Procedimiento de Vaciados

Lima, mayo del 2015

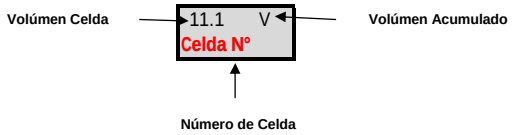
Anexo A.1: CASO 1: CONDICIONES FRÍAS

PLAN DE VACIADO DE CONCRETO MASIVO

Elemento **Fundación de Molino de Bolas**

ELEMENTO				Celdas	
Largo (m)	Ancho (m)	Alto (m)	Volumen (m3)	N° Celdas	Alto Celda
21.40	13.00	2.40	667.7	6	0.40

Volumen Celda	11.1	m3
Ancho Celda	2.14	m
Vel. Vaciado	40.00	m3/hr
Tiempo Vac. Total	16.69	hr
Total de celdas	60	



N° Celda	Altura Acumulada (m)									
6	2.40	11.1 233.7 Celda 21	11.1 300.5 Celda 27	11.1 367.2 Celda 33	11.1 434.0 Celda 39	11.1 500.8 Celda 45	11.1 556.4 Celda 50	11.1 600.9 Celda 54	11.1 634.3 Celda 57	11.1 656.6 Celda 59	11.1 667.7 Celda 60
5	2.00	11.1 166.9 Celda 15	11.1 222.6 Celda 20	11.1 289.3 Celda 26	11.1 356.1 Celda 32	11.1 422.9 Celda 38	11.1 489.6 Celda 44	11.1 545.3 Celda 49	11.1 589.8 Celda 53	11.1 623.2 Celda 56	11.1 645.4 Celda 58
4	1.60	11.1 111.3 Celda 10	11.1 155.8 Celda 14	11.1 211.4 Celda 19	11.1 278.2 Celda 25	11.1 345.0 Celda 31	11.1 411.7 Celda 37	11.1 478.5 Celda 43	11.1 534.1 Celda 48	11.1 578.7 Celda 52	11.1 612.0 Celda 55
3	1.20	11.1 66.8 Celda 6	11.1 100.2 Celda 9	11.1 144.7 Celda 13	11.1 200.3 Celda 18	11.1 267.1 Celda 24	11.1 333.8 Celda 30	11.1 400.6 Celda 36	11.1 467.4 Celda 42	11.1 523.0 Celda 47	11.1 567.5 Celda 51
2	0.80	11.1 33.4 Celda 3	11.1 55.6 Celda 5	11.1 89.0 Celda 8	11.1 133.5 Celda 12	11.1 189.2 Celda 17	11.1 255.9 Celda 23	11.1 322.7 Celda 29	11.1 389.5 Celda 35	11.1 456.2 Celda 41	11.1 511.9 Celda 46
1	0.40	11.1 11.1 Celda 1	11.1 22.3 Celda2	11.1 44.5 Celda 4	11.1 77.9 Celda 7	11.1 122.4 Celda 11	11.1 178.0 Celda 16	11.1 244.8 Celda 22	11.1 311.6 Celda 28	11.1 378.4 Celda 34	11.1 445.1 Celda 40
Avance Parcial		2.15	2.15	2.15	2.15	2.10	2.10	2.15	2.15	2.15	2.15
Avance Acumulado		**2.15**	**4.30**	**6.45**	**8.60**	**10.70**	**12.80**	**14.95**	**17.10**	**19.25**	**21.40**

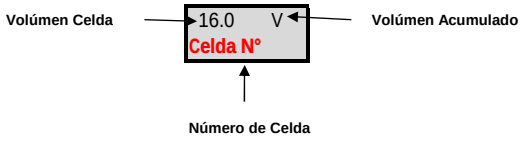
Anexo A.2: CASO 2: CONDICIONES TEMPLADAS

PLAN DE VACIADO DE CONCRETO MASIVO

Elemento **Fundación de Molino de Bolas**

ELEMENTO				Celdas	
Largo (m)	Ancho (m)	Alto (m)	Volumen (m3)	N° Celdas	Alto Celda
29.03	19.56	1.75	993.7	6	0.29

Volumen Celda	16	m3
Ancho Celda	1.84	m
Vel. Vaciado	100	m3/hr
Tiempo Vac. Total	10.50	hr
Total de celdas	66	



N° Celda	Altura Acumulada (m)										
6	1.75	12.9 333.5 Celda 21	12.9 426.6 Celda 27	12.9 519.6 Celda 33	12.9 612.7 Celda 39	12.9 705.8 Celda 45	12.9 792.8 Celda 51	12.9 863.9 Celda 56	12.9 919.0 Celda 60	12.9 958.0 Celda 63	12.9 981.1 Celda 65	12.9 994.0 Celda 66
5	1.46	16.0 240.5 Celda 15	16.0 320.6 Celda 20	16.0 413.7 Celda 26	16.0 506.7 Celda 32	16.0 599.8 Celda 38	16.0 692.8 Celda 44	16.0 779.9 Celda 50	16.0 851.0 Celda 55	16.0 906.1 Celda 59	16.0 945.1 Celda 62	10.1 968.1 Celda 64
4	1.17	16.0 160.3 Celda 10	16.0 224.4 Celda 14	16.0 304.6 Celda 19	16.0 397.6 Celda 25	16.0 490.7 Celda 31	16.0 583.8 Celda 37	16.0 676.8 Celda 43	16.0 763.9 Celda 49	16.0 835.0 Celda 54	16.0 890.0 Celda 58	10.1 929.1 Celda 61
3	0.88	16.0 96.2 Celda 6	16.0 144.3 Celda 9	16.0 208.4 Celda 13	16.0 288.5 Celda 18	16.0 381.6 Celda 24	16.0 474.7 Celda 30	16.0 567.7 Celda 36	16.0 660.8 Celda 42	16.0 747.8 Celda 48	16.0 818.9 Celda 53	10.1 874.0 Celda 57
2	0.58	16.0 48.1 Celda 3	16.0 80.2 Celda 5	16.0 128.2 Celda 8	16.0 192.4 Celda 12	16.0 272.5 Celda 17	16.0 365.6 Celda 23	16.0 458.6 Celda 29	16.0 551.7 Celda 35	16.0 644.8 Celda 41	16.0 731.8 Celda 47	10.1 802.9 Celda 52
1	0.29	16.0 16.0 Celda 1	16.0 32.1 Celda 2	16.0 64.1 Celda 4	16.0 112.2 Celda 7	16.0 176.3 Celda 11	16.0 256.5 Celda 16	16.0 349.5 Celda 22	16.0 442.6 Celda 28	16.0 535.7 Celda 34	16.0 628.7 Celda 40	10 715.8 Celda 46

Avance Parcial	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.16
Avance Acumulado	**1.84**	**3.68**	**5.52**	**7.36**	**9.20**	**11.04**	**12.88**	**14.72**	**16.56**	**18.40**	**19.56**

ANEXO B: Método del ACI 207.2

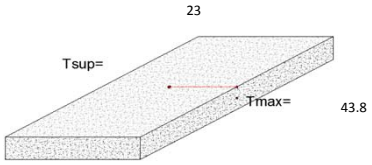
Lima, mayo del 2015

Anexo B.1: CASO 1: CONDICIONES FRÍAS

CÁLCULO DE TEMPERATURA MÁXIMA Y GRADIENTE DE TEMPERATURA ASUMIDO

ALTITUD	4800	msnm
CEMENTO	TIPO IP (II)	
TEMPERATURA COLOCADO	13	°C

L (m)	21.40		
B (m)	13.00		
h (m)	2.40		
Enc. Madera	0.509		
Temp Colocado (°C)	13	55	°F
Temp ambiente (°C)	8	46	°F
Temp minima prom (°C)	5	41	°F
Temp base rocosa (°C)	7	45	°F
Cont. Cemento (kg)	450	11	bolsas de cemento
f'c (kg/cm2)	315		



Tamb<Tcol

Correción por tipo de cemento

Correción por cantidad de cemento

				Grafico 1	Grafico 2			Grafico 3		Grafico 4				
V (por 1m)	A (por 1m)	V/A (m)	V/A (pie)	Dia Pico	Calor disipado (%)	Temp efectivo vaciado (°C)	Temp minima 1 semana (°C)	Incr. temp. para Tipo I	Incremento Tipo II	Incremento Tipo I	Tc (°C)	Tc+f (°C)	Tmax (°C)	Delta
53.80	26.20	2.05	6.72	4 1/2	36%	11.20	6.20	19.4	27.5	33.1	16.2	32.6	43.8	20.8

Temp. Mínima luego de 1 semana (sin encofrado):

V (por 1m)	A (por 1m)	V/A (m)	V/A (pulg)
51.36	26.20	1.96	77.18

Tmin (°C)	Tmax (°C)	Cambio final efectivo (°C)
6.2	43.8	37.6

Se compara con la temperatura de superficie (Tamb+15)

La temperatura máxima que alcanzará el concreto bajo estas condiciones será de:	43.8 °C
El gradiente de temperatura máximo asumido será de:	20.8 °C

ANÁLISIS DE ESFUERZO A PARTIR DEL GRADIENTE DE TEMPERATURA ASUMIDO

$$\sigma = 0.7 * 1.77 * 10^5 * 9.5 * 10^{-6} * (43.8 - 23) = \mathbf{24.5}\ kg/cm^2$$

Ec	214,636.3	Considerar al	65	% del f'c por ser a edad del	4 1/2 día
Esuelo	400,000.0				
Eef	176,708.3				
R	70%				
coef.termico	0.0000095				
Delta	20.84				
Esfuerzo	24.49	Considerar al 65% del f'c por ser a edad temprana			
Resistencia a tracción (12%f'c)	24.57	Considerar al 65% del f'c por ser a edad temprana			

El esfuerzo máximo que se alcanzará en la superficie del concreto será de:	24.5 °C
La resistencia a tracción del concreto será de:	24.6 °C

GRÁFICO 1: Efecto de la temperatura de colocado y de la exposición de la superficie en la edad que alcanza la temperatura máxima.

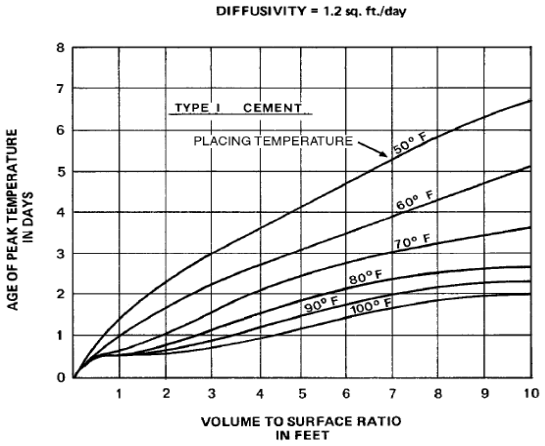


GRÁFICO 2: Flujo de calor entre el aire y el concreto por las diferencias de temperaturas de colocado y del ambiente.

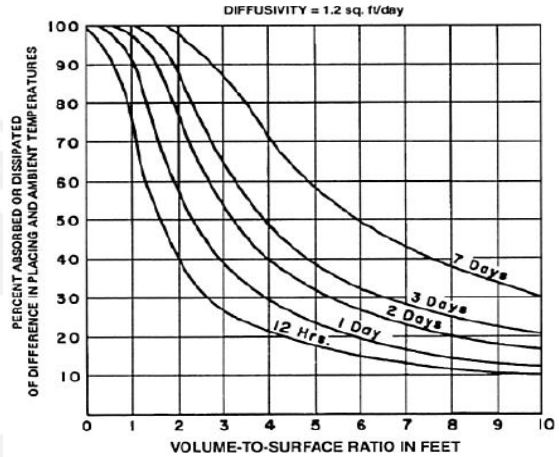


GRÁFICO 3: Incremento de temperatura de un elemento que contiene 223 kg/m3 de cemento para diferentes temperaturas de colocado.

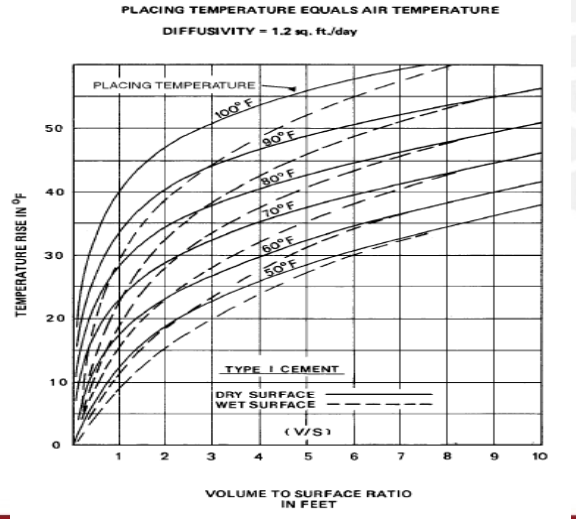
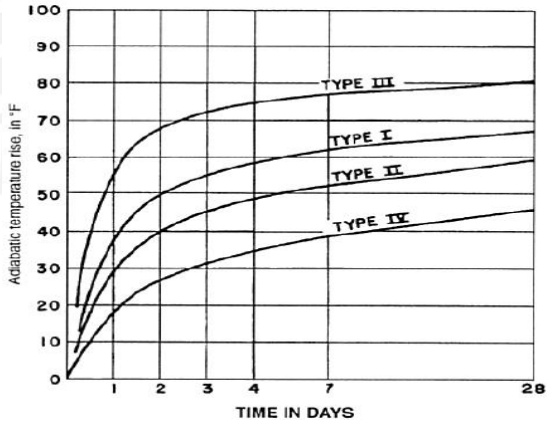


GRÁFICO 4: Incremento de temperatura de un elemento que contiene 223 kg/m3 de cemento para diferentes tipos de cemento.



CONDICIONES INICIALES

ITEM	SIMBOLO	VALOR (°C)
Temperatura de colocado (°C)	T_{COL}	13
Temperatura de ambiente (°C)	T_{AMB}	8
Temperatura de terreno (°C)	T_{M}	7
Temperatura mínima promedio (°C)	T_{A}	5

RESUMEN

ELEMENTO	V/A (pie)	DÍA PICO (día)	T_{PL} (°C)	T_{C} (°C)	T_{C+F} (°C)	T_{FINAL} (°C)	$\Delta T_{asumido}$ (°C)
Molino Bolas 02	6.7	5	11.2	16.2	32.6	43.8	20.8

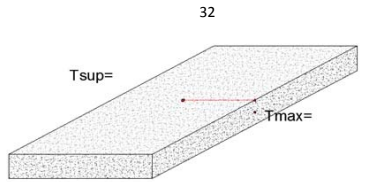
ELEMENTO	L/H	R (%)	E_{eff} (kg/cm^2)	α (1/°C)	ΔT (°C)	σfinal (kg/cm^2)
Molino Bolas 02	8.9	70%	1.8 x 10^5	9.5 x 10^-6	20.8	24.5

Anexo B.2: CASO 2: CONDICIONES TEMPLADAS

CÁLCULO DE TEMPERATURA MÁXIMA Y GRADIENTE DE TEMPERATURA ASUMIDO

ALTITUD	2800	msnm
CEMENTO	TIPO HE (III)	
TEMPERATURA COLOCADO	28	°C

L (m)	29.03		
B (m)	19.56		
h (m)	1.75		
Enc. Madera	0.509		
Temp Colocado (°C)	28	82	°F
Temp ambiente (°C)	17	63	°F
Temp minima prom (°C)	5	41	°F
Temp base rocosa (°C)	16	61	°F
Cont. Cemento (kg)	365	9	bolsas de cemento
f'c (kg/cm2)	280		



Tamb<Tcol

Correción por tipo de cemento

Correción por cantidad de cemento

				Grafico 1	Grafico 2			Grafico 3		Grafico 4				
V (por 1m)	A (por 1m)	V/A (m)	V/A (pie)	Dia Pico	Calor disipado (%)	Temp efectivo vaciado (°C)	Temp minima 1 semana (°C)	Incr. temp. para Tipo I	Incremento Tipo III	Incremento Tipo I	Tc (°C)	Tc+f (°C)	Tmax (°C)	Delta
52.58	32.53	1.62	5.29	2	30%	24.70	10.87	23.9	37.8	27.8	32.5	53.2	77.9	45.9

Temp. Mínima luego de 1 semana (sin encofrado):

V (por 1m)	A (por 1m)	V/A (m)	V/A (pulg)
50.80	32.53	1.56	61.48

Tmin (°C)	Tmax (°C)	Cambio final efectivo (°C)
10.9	77.9	67.0

Se compara con la temperatura de superficie (Tamb+15)

La temperatura máxima que alcanzará el concreto bajo estas condiciones será de: 77.9 °C
El gradiente de temperatura máximo asumido será de: 45.9 °C

ANÁLISIS DE ESFUERZO A PARTIR DEL GRADIENTE DE TEMPERATURA ASUMIDO

$$\sigma = 0.82 * 1.62 * 10^{5} * 9.5 * 10^{-6} * (77.9 - 32) = 58.2\ kg/cm^2$$

Ec	194,422.2	Considerar al	60	% del f'c por ser a edad del	2 días
Esuelo	400,000.0				
Eef	162,775.1				
R	82%				
coef.termico	0.0000095				
Delta	45.88				
Esfuerzo	58.17	Considerar al 60% del f'c por ser a edad temprana			
Resistencia a tracción (12%f'c)	20.16	Considerar al 60% del f'c por ser a edad temprana			

El esfuerzo máximo que se alcanzará en la superficie del concreto será de: 58.2 °C
La resistencia a tracción del concreto será de: 20.2 °C

Observación:

Todos los ábacos usados a continuación, pertenecen al Reporte del Capítulo 4 del Committee del ACI 207.2R .

GRÁFICO 1: Efecto de la temperatura de colocado y de la exposición de la superficie en la edad que alcanza la temperatura máxima.

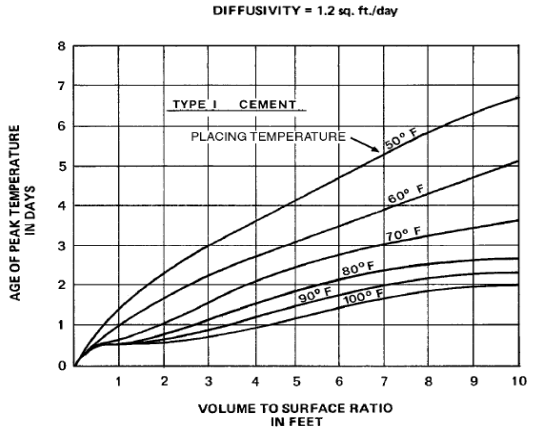


GRÁFICO 2: Flujo de calor entre el aire y el concreto por las diferencias de temperaturas de colocado y del ambiente.

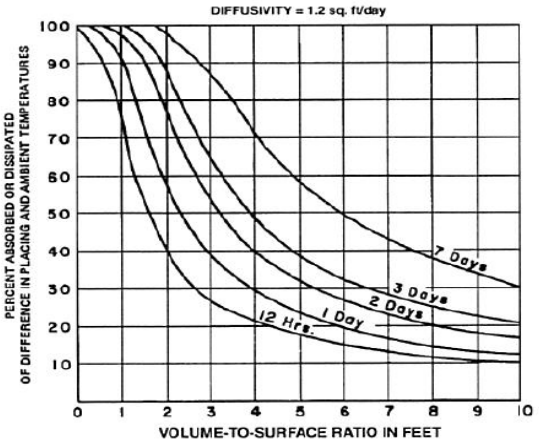


GRÁFICO 3: Incremento de temperatura de un elemento que contiene 223 kg/m3 de cemento para diferentes temperaturas de colocado.

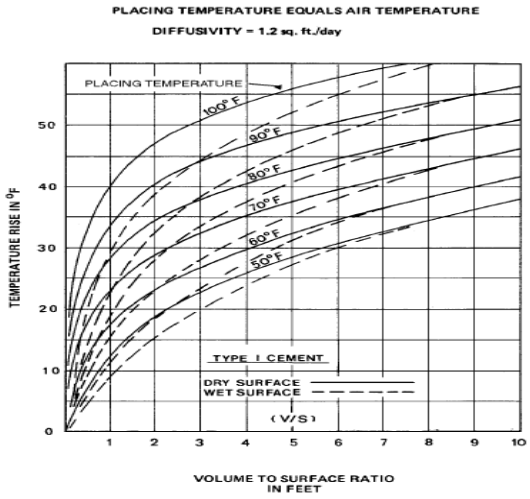
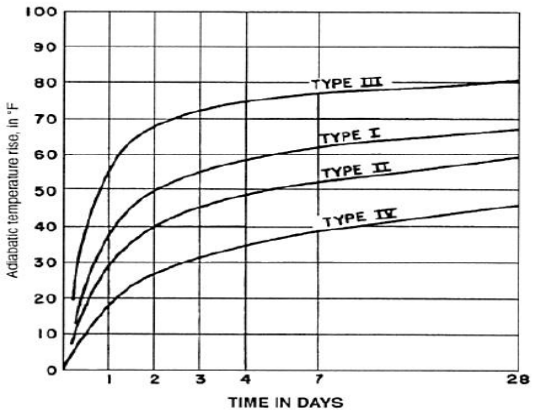


GRÁFICO 4: Incremento de temperatura de un elemento que contiene 223 kg/m3 de cemento para diferentes tipos de cemento.



CONDICIONES INICIALES

ITEM	SIMBOLO	VALOR (°C)
Temperatura de colocado (°C)	T_{COL}	28
Temperatura de ambiente (°C)	T_{AMB}	17
Temperatura de terreno (°C)	T_M	16
Temperatura mínima promedio (°C)	T_A	5

RESUMEN

ELEMENTO	V/A (pie)	DÍA PICO (día)	T_{PL} (°C)	T_C (°C)	T_{C+F} (°C)	T_{FINAL} (°C)	$\Delta T_{asumido}$ (°C)
Molino Bolas 02	5.3	2	24.7	32.5	53.2	77.9	45.9

ELEMENTO	L/H	R (%)	E_{eff} (kg/cm^2)	α (1/°C)	ΔT (°C)	σfinal (kg/cm^2)
Molino Bolas 02	16.6	82%	1.8 x 10^5	9.5 x 10^-6	45.9	58.2

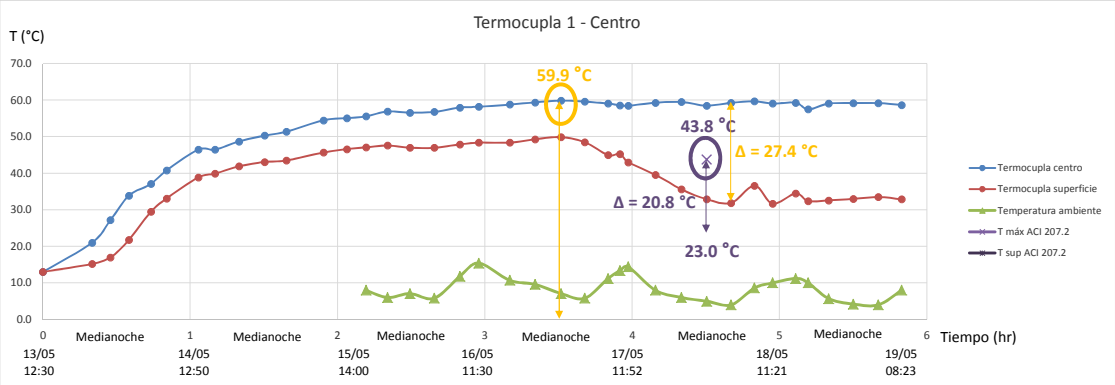
ANEXO C: Registro de Temperaturas

Lima, mayo del 2015

Anexo C.1: CONTROL TEMPERATURAS CONCRETO MASIVO
CASO 1: CLIMA FRÍO

Nº TERMOCUPLA		Termocupla 1				Termocupla 2				Termocupla 3							
FECHA	HORA DE LECTURA	T° NUCLEO 1 (°C)	T° SUPERFICIE 1 (°C)	DIF. T° NUCLEO-SUP. 1 (°C)	CUMPLE	T° NUCLEO 2 (°C)	T° SUPERFICIE 2 (°C)	DIF. T° NUCLEO-SUP. 2 (°C)	CUMPLE	T° NUCLEO 3 (°C)	T° SUPERFICIE 3 (°C)	DIF. T° NUCLEO-SUP. 3 (°C)	CUMPLE	TEMP. MICROCLIMA (°C)	TEMP. AMBIENTE (°C)	TIEMPO TRANSCURRIDO	FRECUENCIA DE TOMA
13/05/2014	12:30	13.0	13.0			13.0	13.0			13.0	13.0						
13/05/2014	20:30	21.0	15.2	5.8	SI	23.1	16.5	6.6	SI	28.6	15.1	13.5	SI			8:00:00	08:00
13/05/2014	23:30	27.2	17.0	10.2	SI	28.9	19.0	9.9	SI	32.8	17.2	15.6	SI			11:00:00	03:00
14/05/2014	02:30	33.9	21.8	12.1	SI	34.7	25.0	9.7	SI	37.2	24.0	13.2	SI			14:00:00	03:00
14/05/2014	06:06	37.1	29.5	7.6	SI	38.1	33.8	4.3	SI	40.3	29.5	10.8	SI			17:36:00	03:36
14/05/2014	08:38	40.8	33.1	7.7	SI	41.5	37.4	4.1	SI	44.1	33.8	10.3	SI			20:08:00	02:32
14/05/2014	13:50	46.5	38.9	7.6	SI	47.9	43.3	4.6	SI	49.6	39.6	10.0	SI			25:20:00	05:12
14/05/2014	16:32	46.5	39.9	6.6	SI	48.1	43.6	4.5	SI	50.1	40.0	10.1	SI			28:02:00	02:42
14/05/2014	20:25	48.7	41.9	6.8	SI	50.3	45.0	5.3	SI	52.0	41.0	11.0	SI			31:55:00	03:53
15/05/2014	00:35	50.3	43.1	7.2	SI	51.9	45.9	6.0	SI	53.5	42.0	11.5	SI			36:05:00	04:10
15/05/2014	04:10	51.4	43.5	7.9	SI	52.4	46.6	5.8	SI	54.5	42.9	11.6	SI			39:40:00	03:35
15/05/2014	10:12	54.5	45.7	8.8	SI	54.8	48.6	6.2	SI	57.6	45.9	11.7	SI			45:42:00	06:02
15/05/2014	14:00	55.1	46.6	8.5	SI	57.3	49.0	8.3	SI	57.7	46.3	11.4	SI			49:30:00	03:48
15/05/2014	17:07	55.6	47.1	8.5	SI	57.9	49.3	8.6	SI	58.3	46.3	12.0	SI	8.0		52:37:00	03:07
15/05/2014	20:38	56.9	47.6	9.3	SI	57.3	49.3	8.0	SI	59.0	45.9	13.1	SI	6.0		56:08:00	03:31
16/05/2014	00:16	56.6	47.0	9.6	SI	58.8	48.8	10.0	SI	59.9	45.4	14.5	SI	7.1		59:46:00	03:38
16/05/2014	04:15	56.8	47.0	9.8	SI	59.1	48.8	10.3	SI	59.3	39.3	20.0	SI	5.8		63:45:00	03:59
16/05/2014	08:24	58.0	47.9	10.1	SI	60.1	49.6	10.5	SI	60.1	44.4	15.7	SI	11.8		67:54:00	04:09
16/05/2014	11:30	58.2	48.4	9.8	SI	60.2	49.7	10.5	SI	60.3	45.5	14.8	SI	15.4		71:00:00	03:06
16/05/2014	16:32	58.8	48.4	10.4	SI	60.7	50.1	10.6	SI	60.5	46.0	14.5	SI	10.7		76:02:00	05:02
16/05/2014	20:40	59.4	49.3	10.1	SI	57.7	49.5	8.2	SI	60.6	45.8	14.8	SI	9.6		80:10:00	04:08
17/05/2014	00:52	59.9	49.9	10.0	SI	61.3	49.9	11.4	SI	60.8	45.7	15.1	SI	7.1		84:22:00	04:12
17/05/2014	04:45	59.6	48.5	11.1	SI	61.2	49.7	11.5	SI	61.0	45.4	15.6	SI	5.8		88:15:00	03:53
17/05/2014	08:33	59.1	45.0	14.1	SI	61.7	46.8	14.9	SI	61.2	45.7	15.5	SI	11.2		92:03:00	03:48
17/05/2014	10:30	58.6	45.3	13.3	SI	60.9	47.5	13.4	SI	60.6	40.7	19.9	SI	13.4	15.0	94:00:00	01:57
17/05/2014	11:52	58.5	43.0	15.5	SI	60.7	45.2	15.5	SI	60.4	38.8	21.6	NO	14.4	16.7	95:22:00	01:22
17/05/2014	16:15	59.3	39.6	19.7	SI	61.2	41.4	19.8	SI	60.6	39.8	20.8	NO	8.0		99:45:00	04:23
17/05/2014	20:30	59.5	35.6	23.9	NO	61.5	38.8	22.7	NO	60.7	35.5	25.2	NO	6.0	0.8	104:00:00	04:15
18/05/2014	00:37	58.5	32.9	25.6	NO	59.9	40.8	19.1	SI	60.7	36.1	24.6	NO	5.0	0.4	108:07:00	04:07
18/05/2014	04:36	59.3	31.9	27.4	NO	60.3	39.9	20.4	NO	60.5	36.2	24.3	NO	4.0	1.1	112:06:00	03:59
18/05/2014	08:24	59.7	36.6	23.1	NO	59.9	39.8	20.1	NO	60.3	38.2	22.1	NO	8.6	8.2	115:54:00	03:48
18/05/2014	11:21	59.1	31.7	27.0	NO	58.3	38.0	20.3	NO	60.2	34.0	26.2	NO	10.0		118:51:00	02:57
18/05/2014	15:07	59.3	34.5	24.8	NO	61.5	35.5	26.0	NO	60.5	34.5	26.0	NO	11.2	20.0	122:37:00	03:46
18/05/2014	17:10	57.5	32.4	25.1	NO	60.5	36.4	24.1	NO	60.5	34.1	26.4	NO	10.0		124:40:00	02:03
18/05/2014	20:30	59.1	32.6	26.5	NO	60.4	37.7	22.7	NO	59.8	29.8	30.0	NO	5.7	1.7	128:00:00	03:20
19/05/2014	00:30	59.2	33.0	26.2	NO	59.9	36.0	23.9	NO	59.9	27.9	32.0	NO	4.2	0.8	132:00:00	04:00
19/05/2014	04:34	59.2	33.5	25.7	NO	60.3	37.2	23.1	NO	59.9	27.2	32.7	NO	4.0	0.7	136:04:00	04:04
19/05/2014	08:23	58.7	32.9	25.8	NO	59.5	36.0	23.5	NO	59.7	34.1	25.6	NO	8.0	9.7	139:53:00	03:49

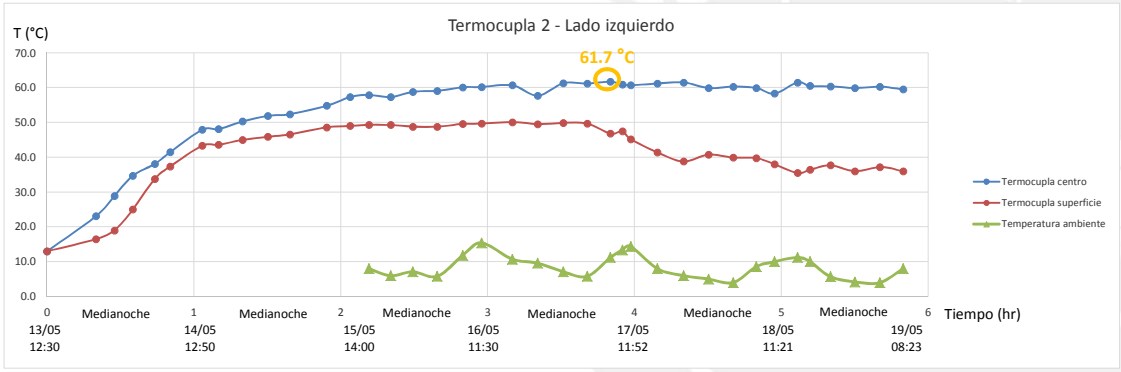
Tmax (°C)	59.9	49.9	27.4		61.7	50.1	26.0		61.2	46.3	32.7	
Tmin (°C)	13.0	13.0	5.8		13.0	13.0	4.1		13.0	13.0	10.0	



TEMPERATURA (°C)	Centro	Superficie	Ambiente	Δ T
Máxima	59.9	49.9	15.4	27.4
Mínima	13.0	13.0	4.0	5.8

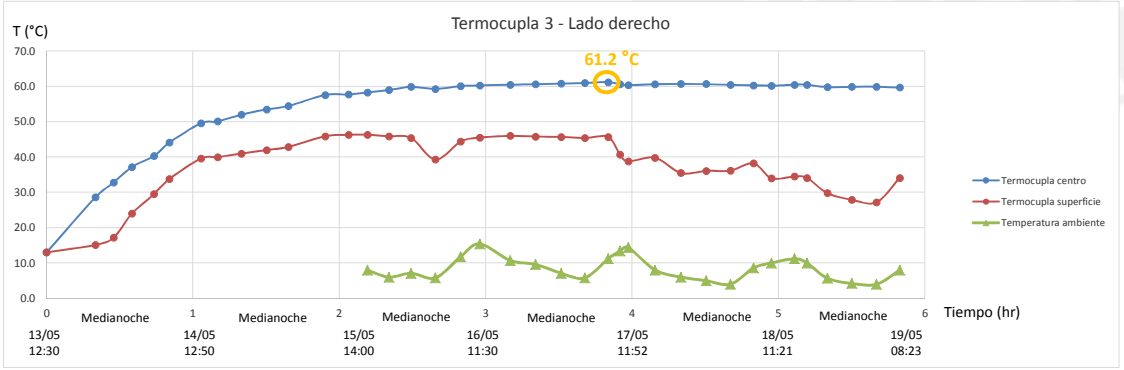
SITUACIÓN	T max (°C)	Día del Tmax	Δ T en el día Tmax (°C)	Δ T max(°C)
ACI 207.2	43.8	4 1/2	-	20.8
CAMPO - CENTRO	59.9	3 1/2	10.0	27.4
CAMPO - IZQUIERDA	61.7	3 1/2	14.8	26.0
CAMPO - DERECHA	61.2	3 1/2	15.5	32.7

CONDICIÓN INICIAL	T vaciado (°C)	T ambiente	T min	T base rocosa
ACI 207.1	13.0	8.0	5.0	7.0
CAMPO	11.0	8.4	4.0	-



TEMPERATURA	Centro	Superficie	Ambiente	Δ T
Máxima	61.7	50.1	15.4	26.0
Mínima	13.0	13.0	4.0	4.1

MÉTODO	T max	Día (Tmax)	Δ T (día Tmax)	Δ T (max)
ACI 207.1	43.8	4 1/2	-	20.8
REAL	61.7	3 1/2	14.8	26.0



TEMPERATURA	Centro	Superficie	Ambiente	Δ T
Máxima	61.2	46.3	15.4	32.7
Mínima	13.0	13.0	4.0	10.0

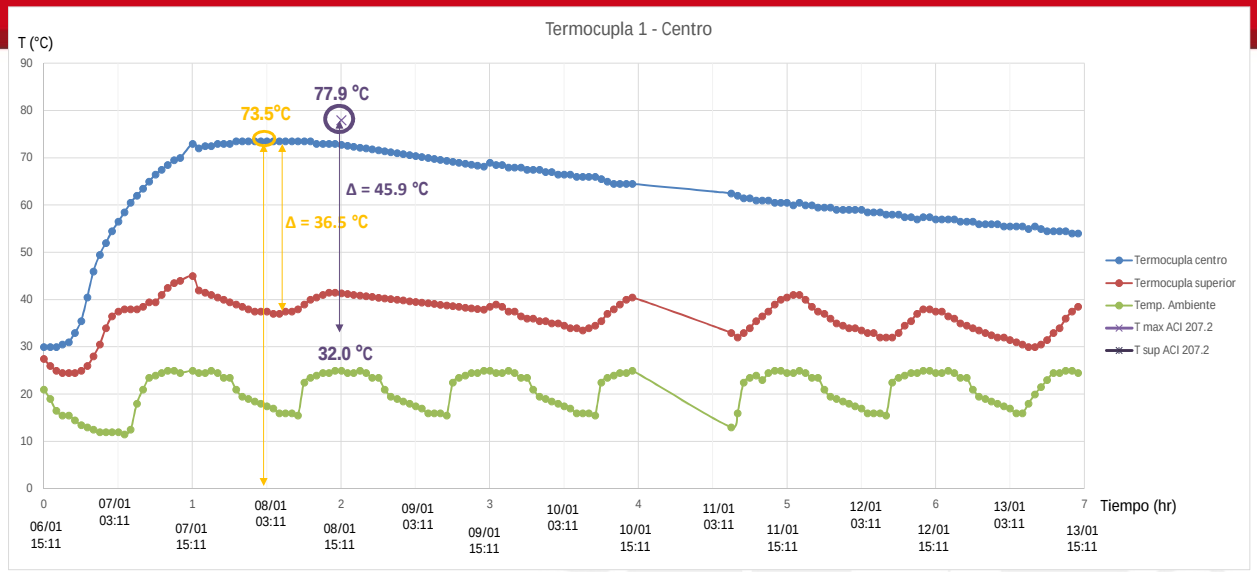
MÉTODO	T max	Día (Tmax)	Δ T (día Tmax)	Δ T (max)
ACI 207.1	43.8	4 1/2	-	20.8
REAL	61.2	3 1/2	15.5	32.7

Anexo C.2: CONTROL TEMPERATURAS CONCRETO MASIVO
CASO 2: CLIMA TEMPLADO

	Nº TERMOCUPLA		1	2	3	DELTA NÚCLEO-SUPERFICIE 1-2			
CONTROL (N°)	FECHA	HORA	T° TERMOCUPLA NÚCLEO CONCRETO (°C)	T° TERMOCUPLA SUPERF. CONCRETO (°C)	TEMP. AMB. (°C)	TEMP. (°C)	CUMPLE	TIEMPO TRANSCURRIDO	FRECUENCIA DE TOMA
1	06/01/2014	03:11:57 p.m.	30	27.5	21	2.5	SI	0	0
2	06/01/2014	04:11:57 p.m.	30	26	19	4.0	SI	1:00:00	1:00:00
3	06/01/2014	05:11:57 p.m.	30	25	16.5	5.0	SI	2:00:00	1:00:00
4	06/01/2014	06:11:57 p.m.	30.5	24.5	15.5	6.0	SI	3:00:00	1:00:00
5	06/01/2014	07:11:57 p.m.	31	24.5	15.5	6.5	SI	4:00:00	1:00:00
6	06/01/2014	08:11:57 p.m.	33	24.5	14.5	8.5	SI	5:00:00	1:00:00
7	06/01/2014	09:11:57 p.m.	35.5	25	13.5	10.5	SI	6:00:00	1:00:00
8	06/01/2014	10:11:57 p.m.	40.5	26	13	14.5	SI	7:00:00	1:00:00
9	06/01/2014	11:11:57 p.m.	46	28	12.5	18.0	SI	8:00:00	1:00:00
10	07/01/2014	12:11:57 a.m.	49.5	30.5	12	19.0	SI	9:00:00	1:00:00
11	07/01/2014	01:11:57 a.m.	52	34	12	18.0	SI	10:00:00	1:00:00
12	07/01/2014	02:11:57 a.m.	54.5	36.5	12	18.0	SI	11:00:00	1:00:00
13	07/01/2014	03:11:57 a.m.	56.5	37.5	12	19.0	SI	12:00:00	1:00:00
14	07/01/2014	04:11:57 a.m.	58.5	38	11.5	20.5	NO	13:00:00	1:00:00
15	07/01/2014	05:11:57 a.m.	60.5	38	12.5	22.5	NO	14:00:00	1:00:00
16	07/01/2014	06:11:57 a.m.	62	38	18	24.0	NO	15:00:00	1:00:00
17	07/01/2014	07:11:57 a.m.	63.5	38.5	21	25.0	NO	16:00:00	1:00:00
18	07/01/2014	08:11:57 a.m.	65	39.5	23.5	25.5	NO	17:00:00	1:00:00
19	07/01/2014	09:11:57 a.m.	66.5	39.5	24	27.0	NO	18:00:00	1:00:00
20	07/01/2014	10:11:57 a.m.	67.5	41	24.5	26.5	NO	19:00:00	1:00:00
21	07/01/2014	11:11:57 a.m.	68.5	42.5	25	26.0	NO	20:00:00	1:00:00
22	07/01/2014	12:11:57 p.m.	69.5	43.5	25	26.0	NO	21:00:00	1:00:00
23	07/01/2014	01:11:57 p.m.	70	44	24.5	26.0	NO	22:00:00	1:00:00
24	07/01/2014	03:12:33 p.m.	73	45	25	28.0	NO	24:00:36	2:00:36
25	07/01/2014	04:12:33 p.m.	72	42	24.5	30.0	NO	25:00:36	1:00:00
26	07/01/2014	05:12:33 p.m.	72.5	41.5	24.5	31.0	NO	26:00:36	1:00:00
27	07/01/2014	06:12:33 p.m.	72.5	41	25	31.5	NO	27:00:36	1:00:00
28	07/01/2014	07:12:33 p.m.	73	40.5	24.5	32.5	NO	28:00:36	1:00:00
29	07/01/2014	08:12:33 p.m.	73	40	23.5	33.0	NO	29:00:36	1:00:00
30	07/01/2014	09:12:33 p.m.	73	39.5	23.5	33.5	NO	30:00:36	1:00:00
31	07/01/2014	10:12:33 p.m.	73.5	39	21	34.5	NO	31:00:36	1:00:00
32	07/01/2014	11:12:33 p.m.	73.5	38.5	19.5	35.0	NO	32:00:36	1:00:00
33	08/01/2014	12:12:33 a.m.	73.5	38	19	35.5	NO	33:00:36	1:00:00
34	08/01/2014	01:12:33 a.m.	73.5	37.5	18.5	36.0	NO	34:00:36	1:00:00
35	08/01/2014	02:12:33 a.m.	73.5	37.5	18	36.0	NO	35:00:36	1:00:00
36	08/01/2014	03:12:33 a.m.	73.5	37.5	17.5	36.0	NO	36:00:36	1:00:00
37	08/01/2014	04:12:33 a.m.	73.5	37	17	36.5	NO	37:00:36	1:00:00
38	08/01/2014	05:12:33 a.m.	73.5	37	16	36.5	NO	38:00:36	1:00:00
39	08/01/2014	06:12:33 a.m.	73.5	37.5	16	36.0	NO	39:00:36	1:00:00
40	08/01/2014	07:12:33 a.m.	73.5	37.5	16	36.0	NO	40:00:36	1:00:00
41	08/01/2014	08:12:33 a.m.	73.5	38	15.5	35.5	NO	41:00:36	1:00:00
42	08/01/2014	09:12:33 a.m.	73.5	39	22.5	34.5	NO	42:00:36	1:00:00
43	08/01/2014	10:12:33 a.m.	73.5	40	23.5	33.5	NO	43:00:36	1:00:00
44	08/01/2014	11:12:33 a.m.	73	40.5	24	32.5	NO	44:00:36	1:00:00
45	08/01/2014	12:12:33 p.m.	73	41	24.5	32.0	NO	45:00:36	1:00:00
46	08/01/2014	01:12:33 p.m.	73	41.5	24.5	31.5	NO	46:00:36	1:00:00
47	08/01/2014	02:12:33 p.m.	73	41.5	25	31.5	NO	47:00:36	1:00:00
48	08/01/2014	03:12:33 p.m.	72.8	41.4	25	31.5	NO	48:00:36	1:00:00
49	08/01/2014	04:12:33 p.m.	72.6	41.2	24.5	31.4	NO	49:00:36	1:00:00
50	08/01/2014	05:12:33 p.m.	72.4	41.1	24.5	31.4	NO	50:00:36	1:00:00
51	08/01/2014	06:12:33 p.m.	72.2	40.9	25	31.3	NO	51:00:36	1:00:00
52	08/01/2014	07:12:33 p.m.	72	40.8	24.5	31.3	NO	52:00:36	1:00:00
53	08/01/2014	08:12:33 p.m.	71.8	40.6	23.5	31.2	NO	53:00:36	1:00:00
54	08/01/2014	09:12:33 p.m.	71.6	40.5	23.5	31.2	NO	54:00:36	1:00:00
55	08/01/2014	10:12:33 p.m.	71.4	40.3	21	31.1	NO	55:00:36	1:00:00
56	08/01/2014	11:12:33 p.m.	71.2	40.2	19.5	31.1	NO	56:00:36	1:00:00
57	09/01/2014	12:12:33 a.m.	71	40.0	19	31.0	NO	57:00:36	1:00:00
58	09/01/2014	01:12:33 a.m.	70.8	39.9	18.5	31.0	NO	58:00:36	1:00:00
59	09/01/2014	02:12:33 a.m.	70.6	39.7	18	30.9	NO	59:00:36	1:00:00
60	09/01/2014	03:12:33 a.m.	70.4	39.6	17.5	30.8	NO	60:00:36	1:00:00
61	09/01/2014	04:12:33 a.m.	70.2	39.4	17	30.8	NO	61:00:36	1:00:00
62	09/01/2014	05:12:33 a.m.	70	39.3	16	30.7	NO	62:00:36	1:00:00
63	09/01/2014	06:12:33 a.m.	69.8	39.1	16	30.7	NO	63:00:36	1:00:00
64	09/01/2014	07:12:33 a.m.	69.6	39.0	16	30.6	NO	64:00:36	1:00:00
65	09/01/2014	08:12:33 a.m.	69.4	38.8	15.5	30.6	NO	65:00:36	1:00:00
66	09/01/2014	09:12:33 a.m.	69.2	38.7	22.5	30.5	NO	66:00:36	1:00:00
67	09/01/2014	10:12:33 a.m.	69	38.5	23.5	30.5	NO	67:00:36	1:00:00
68	09/01/2014	11:12:33 a.m.	68.8	38.4	24	30.4	NO	68:00:36	1:00:00
69	09/01/2014	12:12:33 p.m.	68.6	38.2	24.5	30.4	NO	69:00:36	1:00:00
70	09/01/2014	01:12:33 p.m.	68.4	38.1	24.5	30.3	NO	70:00:36	1:00:00
71	09/01/2014	02:12:33 p.m.	68.2	37.9	25	30.3	NO	71:00:36	1:00:00
72	09/01/2014	03:11:09 p.m.	69	38.5	25	30.5	NO	71:59:12	0:58:36
73	09/01/2014	04:11:09 p.m.	68.5	39	24.5	29.5	NO	72:59:12	1:00:00
74	09/01/2014	05:11:09 p.m.	68.5	38.5	24.5	30.0	NO	73:59:12	1:00:00
75	09/01/2014	06:11:09 p.m.	68	37.5	25	30.5	NO	74:59:12	1:00:00
76	09/01/2014	07:11:09 p.m.	68	37.5	24.5	30.5	NO	75:59:12	1:00:00
77	09/01/2014	08:11:09 p.m.	68	36.5	23.5	31.5	NO	76:59:12	1:00:00
78	09/01/2014	09:11:09 p.m.	67.5	36	23.5	31.5	NO	77:59:12	1:00:00
79	09/01/2014	10:11:09 p.m.	67.5	36	21	31.5	NO	78:59:12	1:00:00
80	09/01/2014	11:11:09 p.m.	67.5	35.5	19.5	32.0	NO	79:59:12	1:00:00
81	10/01/2014	12:11:09 a.m.	67	35.5	19	31.5	NO	80:59:12	1:00:00
82	10/01/2014	01:11:09 a.m.	67	35	18.5	32.0	NO	81:59:12	1:00:00
83	10/01/2014	02:11:09 a.m.	66.5	35	18	31.5	NO	82:59:12	1:00:00
84	10/01/2014	03:11:09 a.m.	66.5	34.5	17.5	32.0	NO	83:59:12	1:00:00
85	10/01/2014	04:11:09 a.m.	66.5	34	17	32.5	NO	84:59:12	1:00:00
86	10/01/2014	05:11:09 a.m.	66	34	16	32.0	NO	85:59:12	1:00:00
87	10/01/2014	06:11:09 a.m.	66	33.5	16	32.5	NO	86:59:12	1:00:00
88	10/01/2014	07:11:09 a.m.	66	34	16	32.0	NO	87:59:12	1:00:00
89	10/01/2014	08:11:09 a.m.	66	34.5	15.5	31.5	NO	88:59:12	1:00:00
90	10/01/2014	09:11:09 a.m.	65.5	35.5	22.5	30.0	NO	89:59:12	1:00:00
91	10/01/2014	10:11:09 a.m.	65	37	23.5	28.0	NO	90:59:12	1:00:00
92	10/01/2014	11:11:09 a.m.	64.5	38	24	26.5	NO	91:59:12	1:00:00
93	10/01/2014	12:11:09 p.m.	64.5	39	24.5	25.5	NO	92:59:12	1:00:00
94	10/01/2014	01:11:09 p.m.	64.5	40	24.5	24.5	NO	93:59:12	1:00:00

95	10/01/2014	02:11:09 p.m.	64.5	40.5	25	24.0	NO	94:59:12	1:00:00
96	11/01/2014	06:09:53 a.m.	62.5	33	13	29.5	NO	110:57:56	15:58:44
97	11/01/2014	07:09:53 a.m.	62	32	16	30.0	NO	111:57:56	1:00:00
98	11/01/2014	08:09:53 a.m.	61.5	33	22.5	28.5	NO	112:57:56	1:00:00
99	11/01/2014	09:09:53 a.m.	61.5	34	23.5	27.5	NO	113:57:56	1:00:00
100	11/01/2014	10:09:53 a.m.	61	35.5	24	25.5	NO	114:57:56	1:00:00
101	11/01/2014	11:09:53 a.m.	61	36.5	23	24.5	NO	115:57:56	1:00:00
102	11/01/2014	12:09:53 p.m.	61	37.5	24.5	23.5	NO	116:57:56	1:00:00
103	11/01/2014	01:09:53 p.m.	60.5	39	25	21.5	NO	117:57:56	1:00:00
104	11/01/2014	02:09:53 p.m.	60.5	40	25	20.5	NO	118:57:56	1:00:00
105	11/01/2014	03:09:53 p.m.	60.5	40.5	24.5	20.0	SI	119:57:56	1:00:00
106	11/01/2014	04:09:53 p.m.	60	41	24.5	19.0	SI	120:57:56	1:00:00
107	11/01/2014	05:09:53 p.m.	60.5	41	25	19.5	SI	121:57:56	1:00:00
108	11/01/2014	06:09:53 p.m.	60	40	24.5	20.0	SI	122:57:56	1:00:00
109	11/01/2014	07:09:53 p.m.	60	38.5	23.5	21.5	NO	123:57:56	1:00:00
110	11/01/2014	08:09:53 p.m.	59.5	37.5	23.5	22.0	NO	124:57:56	1:00:00
111	11/01/2014	09:09:53 p.m.	59.5	37	21	22.5	NO	125:57:56	1:00:00
112	11/01/2014	10:09:53 p.m.	59.5	36	19.5	23.5	NO	126:57:56	1:00:00
113	11/01/2014	11:09:53 p.m.	59	35	19	24.0	NO	127:57:56	1:00:00
114	12/01/2014	12:09:53 a.m.	59	34.5	18.5	24.5	NO	128:57:56	1:00:00
115	12/01/2014	01:09:53 a.m.	59	34	18	25.0	NO	129:57:56	1:00:00
116	12/01/2014	02:09:53 a.m.	59	34	17.5	25.0	NO	130:57:56	1:00:00
117	12/01/2014	03:09:53 a.m.	59	33.5	17	25.5	NO	131:57:56	1:00:00
118	12/01/2014	04:09:53 a.m.	58.5	33	16	25.5	NO	132:57:56	1:00:00
119	12/01/2014	05:09:53 a.m.	58.5	33	16	25.5	NO	133:57:56	1:00:00
120	12/01/2014	06:09:53 a.m.	58.5	32	16	26.5	NO	134:57:56	1:00:00
121	12/01/2014	07:09:53 a.m.	58	32	15.5	26.0	NO	135:57:56	1:00:00
122	12/01/2014	08:09:53 a.m.	58	32	22.5	26.0	NO	136:57:56	1:00:00
123	12/01/2014	09:09:53 a.m.	58	33	23.5	25.0	NO	137:57:56	1:00:00
124	12/01/2014	10:09:53 a.m.	57.5	34.5	24	23.0	NO	138:57:56	1:00:00
125	12/01/2014	11:09:53 a.m.	57.5	35.5	24.5	22.0	NO	139:57:56	1:00:00
126	12/01/2014	12:09:53 p.m.	57	37	24.5	20.0	SI	140:57:56	1:00:00
127	12/01/2014	01:09:53 p.m.	57.5	38	25	19.5	SI	141:57:56	1:00:00
128	12/01/2014	02:09:53 p.m.	57.5	38	25	19.5	SI	142:57:56	1:00:00
129	12/01/2014	03:09:53 p.m.	57	37.5	24.5	19.5	SI	143:57:56	1:00:00
130	12/01/2014	04:09:53 p.m.	57	37.5	24.5	19.5	SI	144:57:56	1:00:00
131	12/01/2014	05:09:53 p.m.	57	36.5	25	20.5	NO	145:57:56	1:00:00
132	12/01/2014	06:09:53 p.m.	57	36	24.5	21.0	NO	146:57:56	1:00:00
133	12/01/2014	07:09:53 p.m.	56.5	35	23.5	21.5	NO	147:57:56	1:00:00
134	12/01/2014	08:09:53 p.m.	56.5	34.5	23.5	22.0	NO	148:57:56	1:00:00
135	12/01/2014	09:09:53 p.m.	56.5	34	21	22.5	NO	149:57:56	1:00:00
136	12/01/2014	10:09:53 p.m.	56	33.5	19.5	22.5	NO	150:57:56	1:00:00
137	12/01/2014	11:09:53 p.m.	56	33	19	23.0	NO	151:57:56	1:00:00
138	13/01/2014	12:09:53 a.m.	56	32.5	18.5	23.5	NO	152:57:56	1:00:00
139	13/01/2014	01:09:53 a.m.	56	32	18	24.0	NO	153:57:56	1:00:00
140	13/01/2014	02:09:53 a.m.	55.5	32	17.5	23.5	NO	154:57:56	1:00:00
141	13/01/2014	03:09:53 a.m.	55.5	31.5	17	24.0	NO	155:57:56	1:00:00
142	13/01/2014	04:09:53 a.m.	55.5	31	16	24.5	NO	156:57:56	1:00:00
143	13/01/2014	05:09:53 a.m.	55.5	30.5	16	25.0	NO	157:57:56	1:00:00
144	13/01/2014	06:09:53 a.m.	55	30	18	25.0	NO	158:57:56	1:00:00
145	13/01/2014	07:09:53 a.m.	55.5	30	20	25.5	NO	159:57:56	1:00:00
146	13/01/2014	08:09:53 a.m.	55	30.5	21.5	24.5	NO	160:57:56	1:00:00
147	13/01/2014	09:09:53 a.m.	54.5	31.5	23	23.0	NO	161:57:56	1:00:00
148	13/01/2014	10:09:53 a.m.	54.5	33	24.5	21.5	NO	162:57:56	1:00:00
149	13/01/2014	11:09:53 a.m.	54.5	34	24.5	20.5	NO	163:57:56	1:00:00
150	13/01/2014	12:09:53 p.m.	54.5	36	25	18.5	SI	164:57:56	1:00:00
151	13/01/2014	01:09:53 p.m.	54	37.5	25	16.5	SI	165:57:56	1:00:00
152	13/01/2014	02:09:53 p.m.	54	38.5	24.5	15.5	SI	166:57:56	1:00:00

Tmax (°C)	73.5	45	25	36.5
Tmin (°C)	30	24.5	11.5	2.5



TEMPERATURA (°C)	Centro	Superficie	Ambiente	Δ T
Máxima	73.5	45.0	25.0	36.5
Mínima	30.0	24.5	11.5	2.0

SITUACIÓN	T max (°C)	Día del Tmax	Δ T en el día Tmax (°C)	Δ T max(°C)
ACI 207.2	77.9	2	-	45.9
CAMPO - CENTRO	73.5	1 1/2	36.0	36.5

CONDICIÓN INICIAL	T vaciado (°C)	T ambiente (°C)	T min (°C)	T base rocosa (°C)
ACI 207.1	28.0	17.0	5.0	16.0
CAMPO	28.0	20.6	11.5	-