CHAPTER 13 TEMPERATURE CONTROL OF CONCRETE

COLD WEATHER

In cold weather, heating of water, aggregates, the plant enclosure or a combination of the three is often needed to bring the concrete temperature into the desirable range (50° to 70° F) to assure normal setting times and strength gains. Often this can be done by simply using heated water as mixing water. Water up to just below the boiling point (200° to 210° F) can be used, but water over 120° F should be used with extreme caution. Care must be taken to assure that hot water cannot be spilled on any personnel. Pressure relief valves and thermostatic controls of boiler systems must be properly adjusted and checked regularly to avoid dangerous explosions or line failures. From a product quality standpoint, it is also important to make certain that very hot water does not come into direct contact with cement. It should be thoroughly blended with the aggregates before the cement is added.

As a general rule, each 5° F increase in water temperature will increase concrete temperature 1° F.

If using hot water does not bring concrete temperatures into the desired range, aggregates can be heated. Aggregate heating can be accomplished by various methods, all of which require special equipment. Options include enclosing and heating the space around the aggregate bins, circulating hot water in coils in the bin or injecting live steam into the bins. Use of steam is effective, but it increases aggregate moisture and can cause slump control problems. Aggregates can also be heated using a sand dryer before being fed into the plant.

As a general rule, aggregate temperature (fine and coarse) must be raised approximately 1.5° F to raise the concrete temperature 1° F.

HOT WEATHER

In hot weather, cooling of concrete is generally not needed until the concrete temperature exceeds 90° F. One of the most common approaches to keep concrete temperatures down is run sprinklers on coarse aggregate stockpiles. To take full advantage of evaporative cooling, sprinklers can be timed to intermittently run 15 to 20 minutes and stop for a similar period of time.

Chilled water systems are sometimes used to produce cool mixing water. At some plants cool water is available year round from a well or from a quarry pond. Figure 13-1 shows the effect of cooling mixing water on concrete temperature. Where additional cooling is needed, ice may be used as a replacement for all or part of concrete mixing water. Many plants utilize crusher-blowers, sometimes referred to as ice-slingers, to shave large blocks of ice and blow the chips into the truck or plant mixer. Hoppers can be mounted on crusher-blowers to enable them to convey bagged ice. Ice cannot be added to a concrete mix in large pieces, since they may not melt completely before the final mixing is completed. Figure 13-2 shows the effect of ice in cooling concrete. Generally, 50 lb. of ice per cubic yard of concrete reduces the fresh concrete temperature 8° to 10° F.

Ice can be used to reduce concrete temperatures up to about 20° F. Additional temperature reduction can be achieved by cooling the coarse aggregate with chilled water prior to batching or through the injection of liquid nitrogen into the mixed concrete. The use of liquid nitrogen for cooling, while effective, is very expensive and fairly difficult. It is generally only used when a project engineer has a special need to keep heat generation in the structure to a minimum.

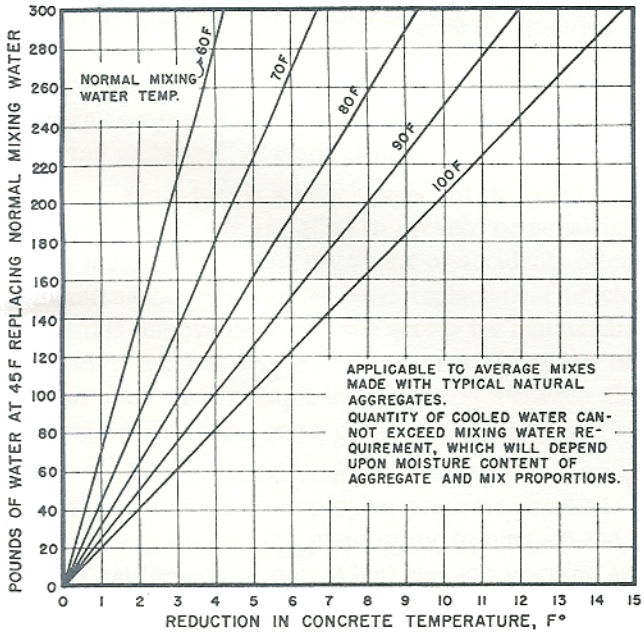
Temperature of Concrete Resulting From Ingredients of Different Temperatures

Based on concrete containing 500 pounds of cement, 300 pounds of mixing water, 2000 pounds of coarse aggregate, and 1200 pounds of sand with the coarse aggregate having 1 percent free surface moisture. Specific heat of cement and aggregates assumed as 0.22; this value provides for usual amounts of absorbed moisture in aggregate.

Average Aggregate Temperature (t_a)	Concrete Temperature (T) for Cement 0 F (t_c) Added Water Temperature (t_w)				Cement 50 F (t_c) Added Water Temperature (t_w)				Cement 100 F (t_c) Added Water Temperature (t_w)				Cement 150 F (t_c) Added Water Temperature (t_w)			
	50	100	150	200(b)	50	100	150	200(b)	50	100	150	200(b)	50	100	150	200(b)
Free Surface Moisture in Sand, 0 percent																
32(a)	33	46	58	71	38	51	63	76	43	56	68	81	48	61	73	86
50	45	58	70	83	50	62	75	88	55	68	80	93	60	72	85	98
70	58	71	83	96	63	76	88	101*	68	80	93	106*	73	85	98	111*
90	71	84	96	109*	76	88	101*	114*	81	94	106*	119*	86	98	111*	124*
110	84	97	109*	122*	89	102*	114*	127*	94	106*	119*	132*	99	111*	124*	137*
Free Surface Moisture in Sand, 4 percent																
32(a)	33	43	53	64	38	48	58	69	42	53	64	74	47	58	68	79
50	45	55	66	76	50	60	71	81	55	66	76	86	60	70	81	91
70	59	69	80	90	64	74	85	95	69	79	90	100*	74	84	94	105*
90	73	83	94	104*	78	88	98	109*	83	93	104*	114*	88	98	108*	119*
110	87	97	107*	118*	92	102*	112*	123*	97	107*	118*	128*	101*	112*	122*	133*
Free Surface Moisture in Sand, 8 percent																
32(a)	32	40	48	57	37	45	53	62	42	50	58	66	47	55	63	71
50	45	53	62	70	50	58	66	75	55	63	72	80	60	68	76	85
70	60	68	76	84	65	73	81	89	70	78	86	94	75	83	91	99
90	74	83	91	99	79	88	96	104*	84	93	101*	109*	89	98	106*	114*
110	89	98	106*	114*	94	102*	111*	119*	99	107*	116*	124*	104*	112*	121*	129*
Free Surface Moisture in Sand, 12 percent																
32(a)	31	37	43	49	36	42	48	54	41	47	53	59	46	52	58	64
50	45	51	57	63	50	56	62	68	55	61	67	73	60	66	72	78
70	61	67	73	79	66	72	78	84	70	77	83	89	75	82	88	94
90	76	82	88	94	81	87	93	99	86	92	98	104*	91	97	103*	109*
110	92	98	104*	110*	97	103*	109*	115*	102*	108*	114*	120*	107*	113*	119*	125*

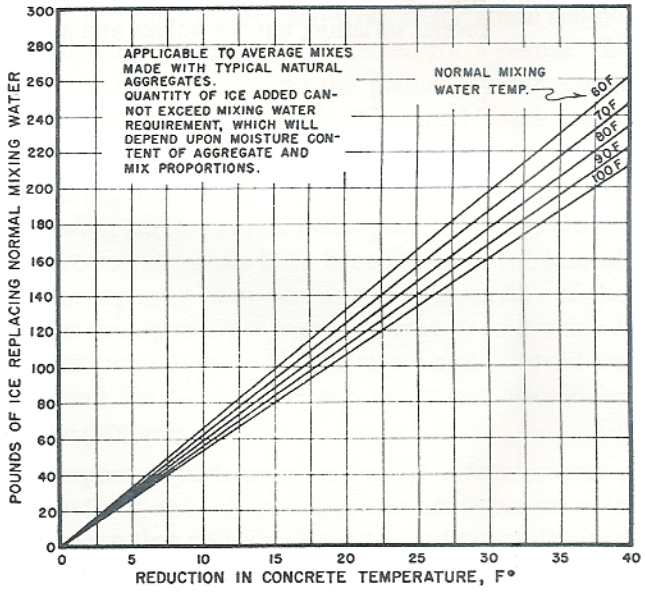
(a) Aggregates free of ice.
(b) Water over 180 F should be mixed with the aggregate for a short period before adding the cement.
* Concrete temperatures above 100 F are not recommended.

Table 13-1



EFFECT OF COOLED MIXING WATER ON CONCRETE TEMPERATURE

Figure 13-1



EFFECT OF ICE IN MIXING WATER ON CONCRETE TEMPERATURE

Figure 13-2