CIP 12 - Hot Weather Concreting

WHAT is Hot Weather?

Hot weather, as defined by ACI 305R, is any combination of the following conditions that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results:

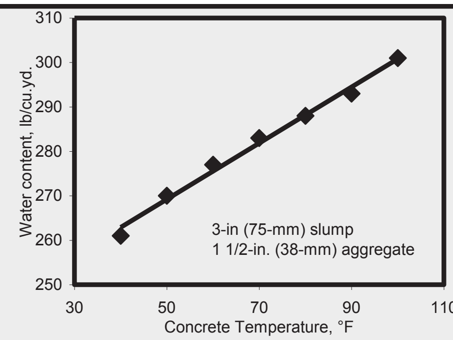
- High ambient temperature
- High concrete temperature
- Low relative humidity
- High wind speed, and
- Solar radiation

Hot weather problems are most frequently encountered in the summer, but the associated climatic factors of high winds, low relative humidity and solar radiation can occur at any time, especially in arid or tropical climates. Hot weather conditions can produce a rapid rate of evaporation of moisture from the surface of the newly placed concrete and accelerated setting time, among other problems. Generally, high relative humidity tends to reduce the effects of high temperature.

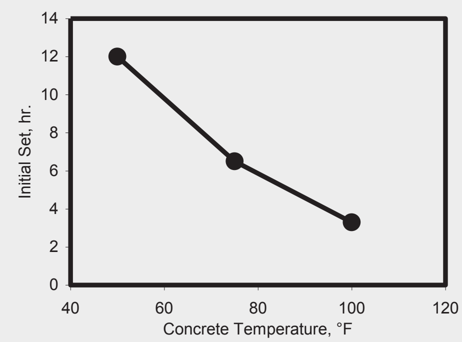
WHY Consider Hot Weather?

Hot weather should be taken into consideration when planning concrete projects because of the potential effects on fresh and newly placed concrete. High concrete temperature causes increased water demand, which, in turn, will increase the water-cementitious materials ratio and result in lower strength and reduced durability. Higher temperatures tend to accelerate the rate of slump loss and can cause loss of entrained air. Temperature also has a major effect on the setting time of concrete: At higher temperatures, concrete will set quicker and finishing operations will need to occur at a faster rate. Concrete that is cured at high temperatures at an early age will not be as strong at later ages as the same concrete cured at temperatures in the range of 70°F (20°C).

High temperatures, high wind velocity, and low relative humidity can affect fresh concrete in two important ways: the high rate of evaporation can



Effect of temperature on water requirement of concrete (Ref. 1)



Effect of temperature on concrete setting time (Ref. 1)

result in plastic shrinkage before concrete sets or early-age drying shrinkage cracking. The evaporation rate removes surface water necessary for hydration unless proper curing methods are employed. Thermal cracking may result from rapid changes in temperature, such as when concrete slabs or walls are placed on a hot day followed by a cool night. High temperature also accelerates cement hydration and contributes to the potential for thermal cracking in thicker concrete sections.

HOW to Concrete in Hot Weather?

The key to successful hot weather concreting is:

1. Recognizing the factors that affect concrete; and
2. Planning to minimize their effects.

Use proven local recommendations for adjusting concrete mixture composition and proportions, such as the use of water reducing and set retarding admixtures. Extended-set control admixtures may also be used for long haul deliveries or in extremely high temperatures. Modifying concrete mixtures to reduce the heat generated by cement hydration, such as the use of an ASTM Type II moderate heat cement, blended cements with a low heat option, and the use of fly ash and slag cement can reduce potential problems with high concrete temperature. Advance planning to schedule concrete delivery to avoid interruptions and delays of placing and finishing is essential. Trucks should be able to discharge immediately and adequate personnel should be available to place and handle the concrete. When possible, avoid the hottest part of the day to place and finish concrete. Do not sprinkle water on the surface of slabs to facilitate finishing. Limits on maximum concrete temperature may be waived by the purchaser if the concrete consistency (slump) is adequate for the placement and excessive water addition is not required.

In the case of extreme temperature conditions or with thicker (mass) concrete sections, the concrete temperature can be lowered by using chilled water or ice as part of the mixing water. Chilled water can reduce concrete temperature by up to 10ºF (6ºC); ice can reduce temperature by up to 20ºF (12ºC) The ready mixed concrete producer uses other measures, such as sprinkling and shading the aggregate, to help lower the temperature of the concrete. For greater reductions in concrete temperature, liquid nitrogen can be injected into concrete mixers. This needs additional setup costs and appropriate precautions to prevent damage to blades and mixer drum.

If low humidity and high winds are predicted windbreaks, sunscreens, mist fogging, or evaporation retardants may be needed to minimize the potential plastic shrinkage cracking in slabs.

References

1. *Hot Weather Concreting*, ACI 305R, American Concrete Institute, Farmington Hills, MI. www.concrete.org
2. *Hot-Weather Concreting*, Chapter in Design and Control of Concrete Mixtures, Portland Cement Association, Skokie, IL., www.cement.org
3. *CIP 9, 11, 24, 29, 34,* Concrete in Practice Series, NRMCA, Silver Spring, MD, www.nrmca.org
4. *Cooling Ready Mixed Concrete*, NRMCA Publication No. 106, NRMCA, Silver Spring, MD.
5. *Effect of Temperature and Delivery Time on Concrete Proportions*, R.D. Gaynor, R.C. Meininger, T.S. Khan, NRMCA Publication 171, NRMCA, Silver Spring, MD.
6. *Keeping Concrete Cool in the Heat of Summer*, K.C. Hover, Concrete Construction, June 1993.

Follow These Rules for Hot Weather Concrete

1. Make appropriate modifications to concrete mixtures to manage rate of slump loss, setting time and other characteristics. Retarders, water reducers, mid and high-range water reducers, extended set-control admixtures, moderate heat of hydration cement, pozzolanic materials, slag cement, or other proven local solutions may be used. Reduced cement content, while ensuring that concrete strength will be attained, may be appropriate. Synthetic fibers may be used to minimize plastic shrinkage cracking (CIP 24).
2. Have adequate manpower to place, finish and cure the concrete. Schedule the rate of concrete delivery that can be managed by available crew and placement equipment.
3. Limit the addition of water at the jobsite—do not exceed the quantity of mixing water established for the concrete mixture. Adding water to concrete that is more than 1½ hours old should be avoided.
4. Slabs on grade placed directly on vapor retarders (CIP 29) will need special precautions when finishing and curing to avoid cracking.
5. On dry and/or hot days, when conditions are conducive for plastic shrinkage cracking, dampen the subgrade, forms and reinforcement prior to placing concrete. Do not allow excessive water to pond.
6. Begin final finishing operations as soon as the water sheen has left the surface; start curing as soon as finishing is completed. Continue curing for at least 3 days; cover the concrete with wet burlap and plastic sheeting to prevent evaporation or use a liquid membrane curing compound, or cure slabs with water (CIP 11). Using white pigmented membrane curing compounds will help with proper coverage and reflect heat from the concrete surface.
7. Protect test cylinders at the jobsite to maintain temperature and moisture for initial curing. Field curing boxes with ice or refrigeration may be necessary to ensure maintaining the required 60 to 80°F (17 to 27°C) for initial curing of cylinders. (CIP 9 and 34)
8. Accelerators may be used in hot weather to expedite finishing operations and to avoid plastic shrinkage cracking.

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