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CONCRETE PROTECTION

Hot Weather Concrete

Placing concrete in hot weather poses one of the greatest challenges in construction. This is because concrete gains the majority of its properties during the temperature-dependent cement hydration reaction. Temperature of the concrete, surrounding air temperatures, and form temperatures can all play a substantial role in the quality of the final concrete product. Large volumes of concrete are placed during the hottest months of the year; managing and mitigating threats associated with placing concrete in hot weather is crucial in today's fast-tracked construction industry. Hot weather is defined as job-site conditions that accelerate the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 80°F or higher, and an evaporation rate that exceeds 1kg/m^2/h or as revised by the Architect/Engineer[1].

Understanding the threats that hot weather poses and how to mitigate those threats in an efficient and effective manner can determine the success of a project.

Some of the main effects of hot weather to concrete are:

- Workability – slump or workability decreases as temperature increases [Fig 1]
- Set time – set time decreases as temperature increases [Fig 2]
- Compressive strength – A high early compressive strength followed by lower long-term compressive strength gains
- Plastic shrinkage cracking – cracks that occur due to rapid evaporation of bleed water.
- Rapid early-age drying shrinkage

[1] American Concrete Institute Manual of Concrete Practice *Specification for Hot Weather Concreting. ACI 305.1-06.* ACI International. Farmington Hills, MI.

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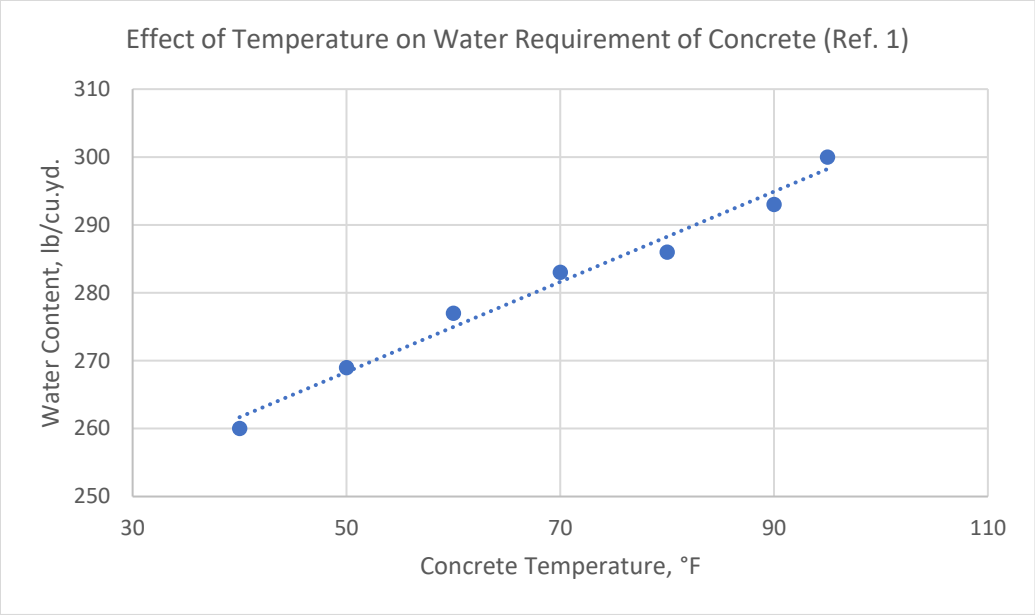

Figure 1: Example of Concrete Temperature Effects on Water Requirements[2]

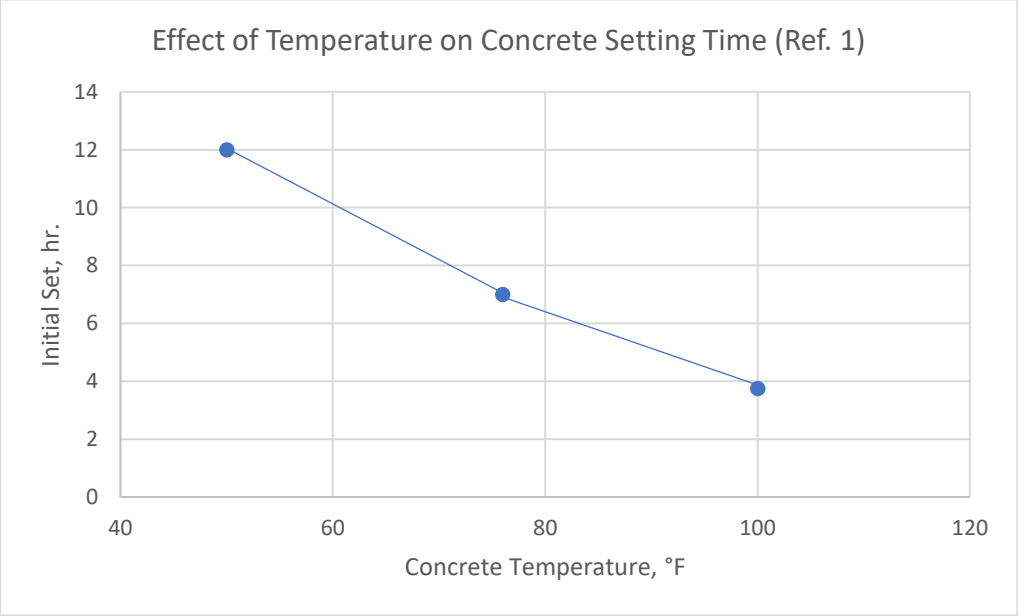

Figure 2: Example of Concrete Temperature Effects on Setting Time

Planning during hot weather concrete placements is recommended in ACI 305 "Hot Weather Concreting". Planning can consist of preplacement conferences, use of admixture and evaporation products, adjusting concrete mix proportions, and others. All of these

[2] Fig. 1 and Fig. 2 National Ready Mixed Concrete Association CIP 12 - Hot Weather Concreting. *Concrete in Practice - What, Why, How?*Retrieved December 18, 2018, (2000) from https://www.nrmca.org/aboutconcrete/cips/12p.pdf.

should be focused on reducing and controlling temperatures and evaporation rates. Wind, relative humidity, ambient temperature, and concrete temperature are the largest factors when considering evaporation rate. The nomograph below has been used throughout the industry for decades and still prevails as the most widely used tool for calculating evaporation rates [Fig. 3]. Commercially-available handheld weather stations with built-in concrete evaporation calculating software have also become popular tools in recent years.

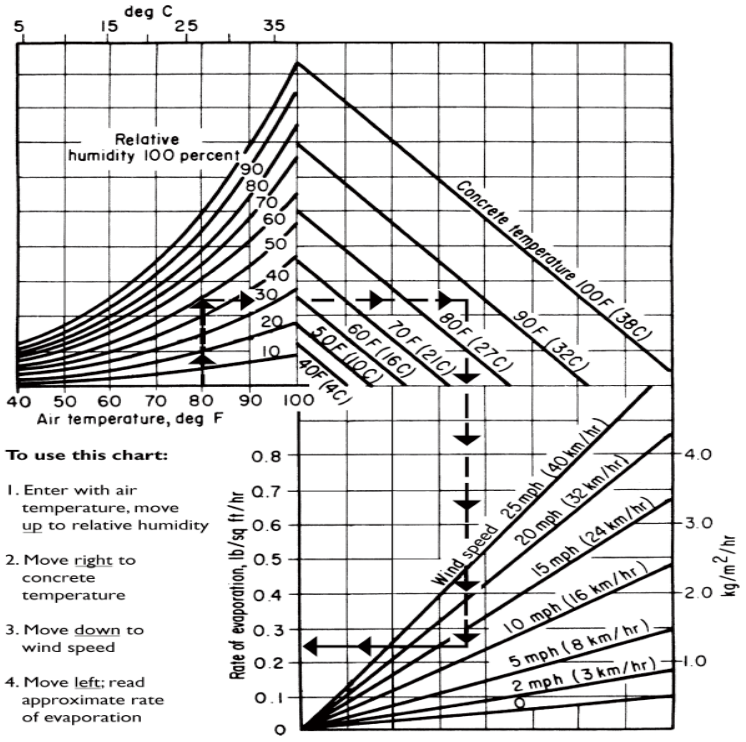

Figure 3: Nomograph for Estimating Concrete Evaporation Rate[3]

There are many different ways to mitigate risks that come with hot weather concreting. A combination of measures taken at the ready-mix plant and the jobsite can allow for concrete to be placed at high temperatures. Acceptable production methods to reduce the temperature of concrete include: shading aggregate stockpiles, sprinkling water on coarse aggregate stockpiles; using chilled water for concrete production; substituting chipped or shaved iced for portions of the mixing water; and cooling concrete materials with liquid nitrogen [1]. Acceptable jobsite measures include timely placement and finishing, control of bleed-water evaporation, curing, and protection. These jobsite measures are all focused on reducing evaporation rates when conditions are threatening. Methods to reduce evaporation rates on site include erecting wind shades and sun shades, using evaporation retarders, using proper curing methods, and others.

[3] Fig. 3 American Concrete Institute Manual of Concrete Practice *Specification for Hot Weather Concreting*. *ACI 305.1-06*. ACI International. Farmington Hills, MI.\

Another consideration is thermal shrinkage of the concrete structure due to rapid drops in concrete temperature of 22°C (40°F) in the first twenty-four hours. Thermal shrinkage can be reduced by using chilled concrete, using cool pipes in the concrete structure, using supplemental cementitious materials (SCM), using mist water, shading the slab, or using curing methods[4].

[4] National Ready Mixed Concrete Association(2009). CIP 42 - Thermal Cracking of Concrete. Retrieved January 17, 2019, from https://www.nrmca.org/aboutconcrete/cips/42p.pdf