TECH Data

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HOT WEATHER CONCRETING

Hot weather introduces problems in manufacturing, placing and curing Portland cement concrete that can adversely affect the properties and serviceability of the hardened concrete. The objectives of this report are to identify these problems and to present hot weather concreting practices which may alleviate adverse effects.

HOT WEATHER DEFINED

For the purpose of this report, hot weather is defined as any combination of high air temperature, low relative humidity, and wind velocity, tending to impair the quality of fresh or hardened concrete or otherwise producing abnormal properties.

The effects of hot weather are most critical during periods of rising temperature, falling relative humidity, or both. They may occur at any time of the year, but generally occur during the summer. Precautionary measures required on a calm, humid day will be less strict than those required on a dry, windy day, even if air temperature is identical.

In the Northwest, the weather is frequently mild and moist and is therefore conducive to concrete placement and finishing. However, it is important to be aware that when concrete and air temperatures are higher than normal, advanced planning of all operations is critical to the successful construction of concrete slabs and structures.

EFFECT OF TEMPERATURE OF CONCRETE AS PLACED

As the temperature of concrete as placed is allowed to increase, the following principal effects will occur

(a) Water content will be increased for a given slump. (Fig. 1)

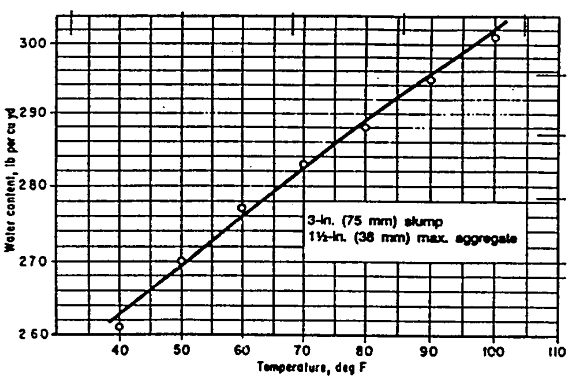


Fig. 1 - The water requirement of a concrete mix increases with an increase in temperature. From USBR Concrete Manual, 8th Edition, Fig. 118.

(b) This increased water content will cause proportionate decrease in strength and durability and an increase in drying shrinkage.

(c) Slump loss will be evident early after mixing and at a more rapid rate. Both are potentials for increased difficulty in concrete handling and placing.

(d) In hot weather there will be a greater probability of the appearance of plastic shrinkage cracks.

(e) In sections of large dimension there will be an increased possibility of differences between interior and exterior temperatures sufficient to cause thermal cracking.

(f) Prompt early curing will be increasingly critical and the lack of it increasingly detrimental.

CONCRETE PROPERTIES

Investigators have shown the detrimental effects of lack of curing and high temperatures on laboratory cast test specimens. It was shown that specimens molded and cured in air at 73° F, 60 percent relative humidity, and at 100° F (38° C) 25 percent relative humidity, produced strength of only 73 and 62 percent respectively, of that obtained for standard specimens moist cured at 73° F for 28 days. It was also found that the longer the delay between casting and placing into standard moist storage, the greater the strength reduction.

These tests illustrate that improper curing, especially in combination with high placement temperatures, impairs the hydration process and reduces strength.

Concrete mixed, placed and cured at elevated temperatures normally develops higher early strengths than concretes produced and cured at normal temperatures, but at 28 days or later strengths are generally lower.

Plastic shrinkage cracking is frequently associated with hot weather concreting and may develop whenever the rate of evaporation is greater than the rate at which water rises to the surface (bleeding) of the recently placed concrete. High concrete temperature, high air temperature, high wind and low humidity, or combinations thereof, cause rapid evaporation which significantly increases the likelihood that plastic shrinkage cracking will occur.

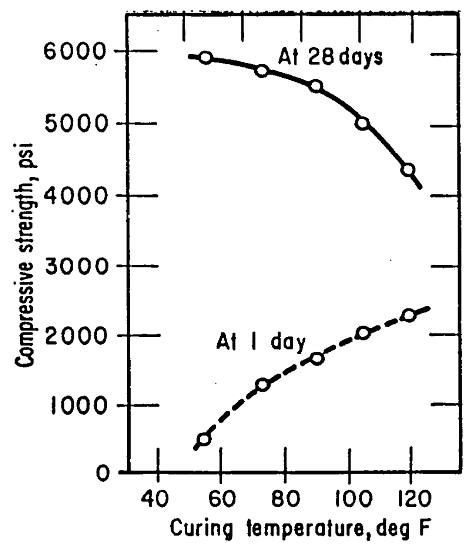


Fig. 2 - One-day strength increases with increasing curing temperature but 28-day strength decreases with increasing curing temperature. Reference: "Structures and Physical Properties of Cement Pastes" (Verbeck and Helmuth, Japanese Symposium)

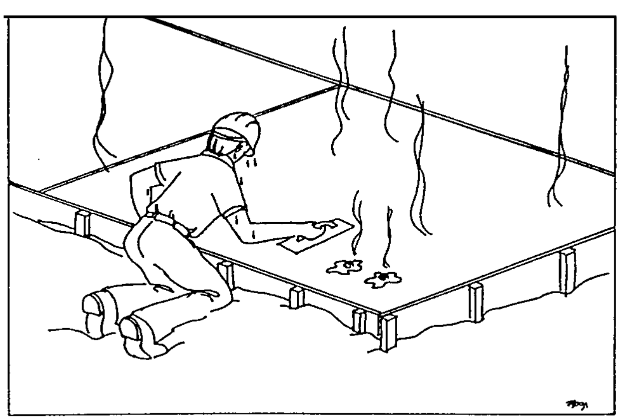
High evaporation rates can result even at relatively low temperatures if the humidity is low and/or wind velocity and concrete temperatures are high.

Increased drying shrinkage results from greater water demand. Subsequent cooling from high temperatures at which the concrete hardens will also increase the cracking tendency of concrete.

PRODUCTION AND DELIVERY

Cement hydration, temperature rise, slump loss and loss of air all increase with passage of time; thus, the period between mixing and delivery should be kept to an absolute minimum. With ready-mixed concrete operations, this presents some special problems. Attention should be given to coordinating the dispatching of trucks with the rate of placement to avoid delays in delivery.

Since the greatest portion of concrete is aggregate, reduction of aggregate temperature brings about the greatest reduction in concrete temperature. Thus, all practical means should be employed to keep the aggregates as cool as possible. This can be done, for example, by shading the aggregate supplies. Sprinkling or fog spraying of coarse aggregate stockpiles is effective in reducing aggregate temperatures by evaporative and direct cooling. Such sprinkling should not be done haphazardly, since this leads to excessive variation in surface moisture and thereby impairs uniformity of slump. The benefits, however, are valuable and warrant close attention.



Curing must begin as soon as possible!

PLACING AND CURING

Preparations for placing and curing in hot weather include recognition at the start of the work that certain abnormal conditions will exist which will require preparation that cannot readily be provided the last minute before concrete is placed. If air and concrete temperatures are expected to be high, preparation must be made to transport, place, consolidate and finish the concrete at the fastest possible rate. Placing slabs on grade after the walls and the roof are up, erecting windbreaks, using monomolecular sprays designed to minimize evaporation during finishing, or using fog sprays should result in higher quality flatwork during hot weather.

The sub-grade must be smooth, flat, adequately compacted and thoroughly moistened for control joints to function properly, i.e. to crack where they are supposed to! Consideration of proper joint spacing is important in year-round placement, but is especially so during hot weather concreting.

Saw cutting of a slab should take place as soon as possible and, depending on conditions and slab thickness, may have to start as soon as the blade can be placed into the fresh concrete without raveling. New saws are available to cut fresh concrete.

PLACEMENT AND FINISHING

Each operation in concrete finishing should be carried out promptly when the concrete is ready for it. It is necessary to make sure that concrete is not placed in the forms faster than it can be properly consolidated or finished. Delays increase slump loss and invite the addition of water to offset it.

In summary, *"providing proper temperature and moisture conditions for curing of concrete is much more critical and important in hot weather than under normal temperatures. It is, therefore, of first importance that curing be promptly commenced, ample in coverage, and continued without interruption." (Reference: ACI 305R-89)*

TESTING CONCRETE

Tests on fresh concrete samples should be conducted and test specimens prepared without delay. High temperature, low relative humidity and drying winds are detrimental to all concrete and particularly to the relative small volume of concrete used for making tests and molding specimens. Leaving the sample exposed to hot sun, wind or dry air can seriously affect test results. Cure the specimens in the field at temperatures between 60° and 80° F (ASTM C31).

Refer to TECH data issue #2 "Curing of Concrete Test Specimens" for proper curing procedures.

Tech Tips

- Avoid higher water demand in hot weather
- Keep concrete temperature as low as possible
  - ▸ discharge concrete in a timely manner
- Keep aggregates as cool as possible
  - ▸ saturate coarse aggregate stockpiles
- Protect concrete from evaporation
- Proper joint spacing and timing is critical
- Curing must commence as soon as possible
- Provide proper curing for test specimens
- Saturate subgrade prior to placement

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