How to Concrete in Cold and Hot Weather

1

Professional Development Hours (PDH) or

Continuing Education Hours (CE)

Online PDH or CE course

Contact information

www.DiscountPDH.com

fdapdh@gmail.com

Telephone: 713-787-6810

Corporate Mailing address:

2500 Tanglewilde, Suite 220

Houston, Texas 77063

For all your questions and instructor support please contact us via email or phone.

All emails and phone calls are addressed within 24 hours.

Operating hours: 9 AM – 4 PM central time

Tel: 713-787-6810

Fax: 713-787-6825

Email: fdapdh@gmail.com

Table of Contents

Cold Weather Concreting

WHAT is Cold Weather?

Cold weather is defined as a period when the average daily temperature falls below 40°F (4°C) for more than three successive days. These conditions warrant special precautions when placing, finishing, curing and protecting concrete against the effects of cold weather. Since weather conditions can change rapidly n the winter months, good concrete practices and proper planning are critical.

WHY Consider Cold Weather?

Successful cold-weather concreting requires an understanding of the various factors that affect concrete properties.

In its plastic state, concrete will freeze if its temperature falls below about 25°F (-4°C). If plastic concrete freezes, its potential strength can be reduced by more than 50% and its durability will be adversely affected. Concrete should be protected from freezing until it attains a minimum compressive strength of 500 psi (3.5 MPa), whish is about two days after placements for most concrete maintained at 50°F (10°C).

Low concrete temperature has a major effect on the rate of cement hydration, which results in slower setting and rate of strength gain. A good rule of thumb is that a drop in concrete temperature by 20 F (10 C) will approximately double the setting time. The slower rate of setting and strength gain should be accounted for when scheduling construction operations, such as form removal.

Concrete in contact with water and exposed to cycles of freezing and thawing, even if only during construction, should be air-entrained. Newly placed concrete is saturated with water and should be protected from cycles of freezing and thawing until it has attained a compressive strength of at least 3500 psi (24.0 MPa).

Cement hydration is a chemical reaction that generates heat. Newly placed concrete should be adequately insulated to retain this heat and thereby maintain favorable curing temperatures. Large temperature differences between the surface and the interior of the concrete mass should be prevented as cracking may result when this difference exceeds about 35°F (20°C).

Insulation or protective measure should be gradually removed to avoid thermal shock.

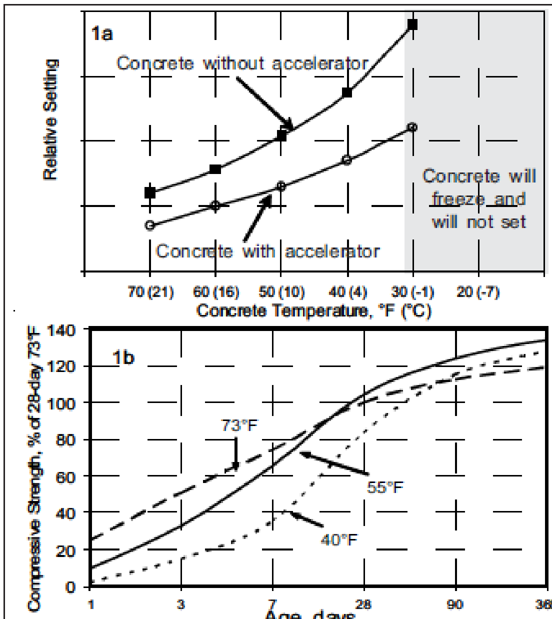


Figure 1 Effect of Temperature on Set Time (1a) and Strength (1b) of Concrete

HOW to Place Concrete in Cold Weather?

Recommended concrete temperatures at the time of placement are show below. The ready mixed concrete producer can control concrete temperature by heating the mixing water and/or the aggregates and furnish concrete in accordance with the guidelines in ASTM C 94.

Section Size, minimum dimension, inch [mm]	Concrete temperature as placed
less than 12 [300]	55°F [13°C]
12 - 36 [300 - 900]	50°F [10°C]
36 - 72 [900 - 1800]	45°F [7°C]

Cold weather concrete temperature should not exceed these recommended temperatures by more than 20°F (10°C). Concrete at a higher temperature requires more mixing water, has a higher rate of slump loss, and is more susceptible to cracking. Placing concrete in cold weather provides the opportunity for better quality, as cooler initial concrete temperature will typically result in higher ultimate strength.

Slower setting time and strength gain of concrete during cold weather typically delays finishing operations and from removal. Chemical admixtures and other modifications to the concrete mixture can accelerate the rate of setting and strength gain. Accelerating chemical admixtures, conforming to ASTM C 494—Types C (accelerating) and E (water -reducing and accelerating), are commonly used in the wintertime. Calcium chloride is a common and effective accelerating admixture but should not exceed a maximum dosage of 2% by weight of cement. Non-chloride, non-corrosive accelerators should be sued for prestressed concrete or when corrosion of steel reinforcement or teal in contact with concrete is a concern. Accelerating admixtures do not prevent concrete from freezing and their used does not preclude the requirements for concrete temperature and appropriate curing and protection from freezing.

Accelerating the rate of set and strength gain can also be accomplished by increasing the amount of Portland cement or by using Type III cement (high early strength). The relative percentage of fly ash or ground slag in the cementitious material component may be reduce din cold weather but this may not be possible if the mixture has been specifically designed d for durability. The appropriate decision should afford an economically viable solution with the least impact on the ultimate concrete properties.

Concrete should be placed at the lowest practical slump as this reduces bleeding and setting time. Adding 1 to 2 gallons of water per cubic yard (5 to 10 L/m3) will delay stet time by ½ to 2 hours. Retarded set times will prolong the duration of bleeding. Do not start finishing operations while the concrete continues to bleed as this will result in a weak surface.

Adequate preparations should be made prior to concrete placement. Snow, ice, and frost should be removed and the temperature of surfaces and metallic embedment in contact with concrete should be above freezing. This might require insulating or heating subgrades and contact surfaces prior to placement.

Materials and equipment should be in place to protect concrete, both during and after placement, from early age freezing and to retain the heat generated by cement hydration. Insulated blankets and tarps, as well as straw covered with plastic sheets, are commonly used measures. Enclosures and insulated forms may be needed for additional protection depending on ambient conditions. Corners and edges are most susceptible to heat loss and need particular attention. Fossil-fueled heaters in enclosed spaces should be vented for safety reasons and to prevent carbonation of newly placed concrete surfaces, which causes dusting.

The concrete surface should not be allowed to dry out while it is plastic as this causes plastic shrinkage cracks. Subsequently, concrete should be adequately cured. Water curing is not recommended when freezing temperatures are imminent. Used membrane-forming curing compounds or impervious paper and plastic sheets for concrete slabs.

Forming material, except for metals, sere to maintain and evenly distribute heat, thereby providing adequate protection in moderately cold weather. With extremely cold temperatures, insulating blankets or insulated forms should be used, especially for thin sections. Forms should not be stripped for 1 to 7 days depending on the setting characteristics, ambient conditions and anticipated loading on the structure. Field-cured cylinders or nondestructive methods should be used to estimate in-place concrete strength prior to stripping from or applying loads. Field-cured cylinders should not be used for quality assurance.

Special care should be taken with concrete test specimens used for acceptance of concrete. Cylinders should be stored in insulated boxes, which may need temperature controls, to insure that they are cured at 60°F to 80°F (16 to 27°C) for the first 24 to 48 hours. A minimum/maximum thermometer should be placed in the curing box to maintain a temperature record.

Cold Weather Concreting Guidelines

1. Use air-entrained concrete when exposure to moisture and freezing and thawing conditions are expected.
2. Keep surfaces in contact with concrete free of ice an snow and at a temperature above freezing prior to placement.
3. Place and maintain concrete at the recommended temperature.
4. Place concrete at the lowest practical slump.
5. Protect plastic concrete from freezing or drying.
6. Protect concrete from early-age freezing and thawing cycles until it has attained adequate strength.
7. Limit rapid temperature changes when protective measures are removed.

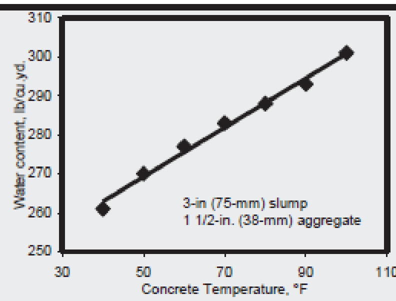
Hot Weather Concreting

WHAT is Hot Weather?

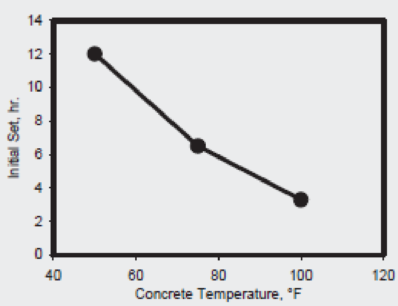
Hot weather, as defined by ACI 305R, is any combination of the following conditions that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results:

- 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.



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



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

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 a high temperature at an early age will no be as strong at later ages as the same concrete cured at temperatures in the rage on 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 result in plastic 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.

Used proven local recommendations for adjusting concrete mixture composition and proportions, such as the use of weather 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 used of an ASTM Type II moderate heat cement, blended cements with a low heat potion, 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. Truck 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 the slabs to facilitate finishing. Limits on maximum concrete temperature may be waived by the purchaser if the concrete consistency (slum) is adequate of 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 10°F (6°C); ice can reduce temperature by up to 20°F (12°C). 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.

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 sued. Reduced cement content, while ensuring that concrete strength will be attained, may be appropriate. Synthetic fibers may be used to minimize plastic shrinkage cracking (CIP24).
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 1.5 hours old should be avoided.
4. Slabs on grade place 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 require 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.

References

Cold Weather Concreting, ACI 306R, American Concrete Institute, Farmington Hills, MI
Design and Control of Concrete Mixtures, Portland Cement Association, Skokie, IL.
ASTM C94 *Standard Specification for Ready Mixed Concrete*, ASTM, West Conshohocken, PA.
ASTM C 31 *Making and Curing Concrete Test Specimens in the Field*, ASTM, West Conshohocken, PA.
Cold Weather Ready Mixed Concrete, NRMCA Pub 130, NRMCA, Silver Spring, MD.
Cold-Weather Finishing, Concrete Construction, November 1993
Hot Weather Concreting, ACI 305R, American Concrete Institute, Farmington Hills, MI. www.concrete.org
Hot-Weather Concreting, Chapter in Design and Control of Concrete Mixtures, Portland Cement Association, Skokie, IL., www.cement.org
CIP 9, 11, 24, 29, 34, Concrete in Practice Series, NRMCA, Silver Spring, MD, www.nrmca.org
Cooling Ready Mixed Concrete, NRMCA Publication No. 106, NRMCA, Silver Spring, MD.
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.
Keeping Concrete Cool in the Heat of Summer, K.C. Hover, Concrete Construction, June 1993