Concrete in Practice
What, why & how?
NRMCA

CIP 27 - Cold Weather Concreting

WHAT is Cold Weather?

Cold weather is defined as a period when for more than 3 consecutive days the average daily temperature is less than 40°F [5°C] and the air temperature is not more than 50°F [10°C] for more than one-half of any 24-hr period. These conditions warrant special precautions when placing, finishing, curing and protecting concrete against the effects of cold weather. Since weather conditions can change rapidly in the winter months, good concrete practices and proper planning are critical.

WHY Consider Cold Weather?

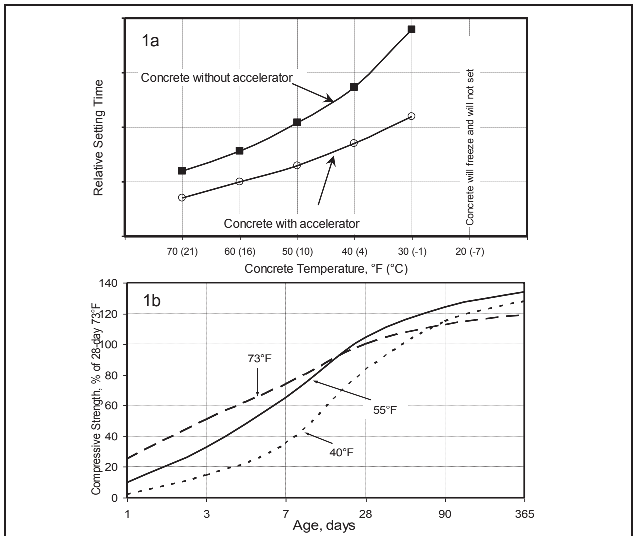
Successful cold-weather concreting requires an understanding of the various factors that affect concrete properties.

In its fresh state concrete freezes if its temperature falls below about 25°F [-4°C]. The potential strength of frozen concrete can be reduced by more than 50% and it will not be durable. Concrete should be protected from freezing until it attains a compressive strength of 500 psi [3.5 MPa] - about two days after placement.

Concrete at a low temperature has a slower setting and rate of strength gain. A rule of thumb is that a drop in concrete temperature by 20°F [10°C] will approximately double the setting time. These factors should be accounted for when scheduling construction operations, such as form removal.

Concrete that will be in contact with water and exposed to cycles of freezing and thawing 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].

The reaction between cement and water, called hydration, generates heat. Insulating concrete retains heat and maintains favorable curing temperatures. Temperature differences between the surface and the interior of concrete should be controlled. Thermal cracking may occur when the difference exceeds about 35°F [20°C]. Insulation or protective measures should be gradually removed to avoid thermal shock.



Effect of temperature on concrete set time and strength

HOW to Place Concrete in Cold Weather?

Recommended concrete temperatures at the time of placement are shown below. The ready mixed concrete producer can control concrete temperature and furnish concrete to comply.

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]

Concrete temperature should not exceed these 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. Concreting in cold weather provides the opportunity for better quality, as cooler initial concrete temperature will typically result in higher ultimate strength and improved durability.

In cold weather, slower setting time and rate of strength gain of concrete can delay finishing operations and form removal. Chemical admixtures and other materials can be used to offset these effects. Accelerating admixtures, conforming to ASTM C 494—Types C (accelerating) and E (water -reducing and accelerating), are commonly used.

Calcium chloride is an effective accelerating admixture, but should not exceed a dosage of 2% by weight of cement. Non-chloride, non-corrosive accelerators should be used for prestressed concrete or when corrosion of steel reinforcement or metal in contact with concrete is a concern. Accelerating admixtures do not prevent concrete from freezing and their use does not preclude the requirements appropriate curing and protection from freezing.

Rate of setting and strength gain increased by increasing portland cement content or by using a Type III cement (high early strength). The quantity of fly ash or slag cement in concrete may be reduced in cold weather for a similar effect. This may not be possible if a minimum quantity of SCM is required for durability. The selected solution should be economical and not compromise on the required concrete performance.

Concrete should be placed at the lowest practical slump. Adding water to achieve slump can delay setting time and prolong the duration of bleeding, thereby impacting finishing operations.

Adequate preparations should be made prior to concrete placement. Snow and ice should be removed and the temperature of surfaces and metallic embedments 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 from freezing temperature and for adequate curing, both during and after placement. 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. 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 before it sets as this can cause plastic shrinkage cracks. Subsequently, concrete should be adequately cured. Water curing is not recommended when freezing temperatures are imminent. Use membrane-forming curing compounds or impervious paper and plastic sheets for concrete slabs.

Forming materials, except for metals, maintain and evenly distribute heat and provide adequate protection in moderately cold weather. In extremely cold temperatures, insulating blankets or forms should be used, especially for thin sections. Forms should not be stripped for 1 to 7 days depending on rate of strength gain, 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 forms or applying loads. Removal of protective measures and formwork should not cause thermal shock to the concrete.

Concrete test specimens used for acceptance of concrete should be carefully managed. In accordance with ASTM C31, cylinders should be stored in insulated containers, which may need temperature controls, to insure that they are cured at 60°F to 80°F [16°C 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 of curing test specimens at the jobsite.

References

1. *Cold Weather Concreting*, ACI 306R, American Concrete Institute, Farmington Hills, MI.
2. *Design and Control of Concrete Mixtures*, Portland Cement Association, Skokie, IL.
3. ASTM C94 *Standard Specification for Ready Mixed Concrete*, ASTM, West Conshohocken, PA.
4. ASTM C31 *Making and Curing Concrete Test Specimens in the Field*, ASTM, West Conshohocken, PA.
5. *Cold-Weather Finishing*, Concrete Construction, November 1993

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 and 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 fresh 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.

1998, 2014