Triangle Tech Tips

References and resources from Triangle Ready Mix

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Placing Concrete During Cold Weather

How does cold weather affect concrete production and placement?

During cold weather, when the average daily temperature stays under 40°F for over three consecutive days, it's important to take extra care when working with concrete. Special care should be taken when placing it, finishing it and letting it set, to mitigate the impact of cold weather. Given the swift changes in weather that often occur in winter, adherence to sound concrete practices and meticulous planning becomes crucial. To work with concrete in cold weather, it's important to know what factors affect concrete properties.

When concrete is still wet and moldable (we call this the "plastic state"), it can freeze if the temperature drops below about 25°F. If this happens, the concrete's strength could drop by more than 50%, and it won't last as long. To prevent freezing, it's crucial to keep the concrete protected until it's strong enough, with a minimum compressive strength of 500 psi. This usually takes about two days after it's placed and maintained at a temperature of 50°F.

Low concrete temperature has a significant impact on the speed of cement hydration, leading to a slower setting and a slower rate of strength gain. It's helpful to follow this general guideline: a decrease in concrete temperature of **20°F** will roughly **double** the time it takes to set. When planning construction operations, such as removal of forms, it's essential to consider the slower setting and strength gain to ensure everything is properly scheduled.

Concrete that is in contact with water and exposed to cycles of freezing and thawing should be air-entrained. Even if the freezing cycles only occur during construction, the concrete should be air-entrained. Freshly poured concrete is saturated with water and should be protected from cycles of freezing and thawing until it has gained a compressive strength of at least 3500 psi.

Cement hydration is a chemical reaction that generates heat. To keep the concrete curing well, it's important to keep this heat. Insulate freshly poured concrete to maintain good curing temperatures. Avoid large temperature differences between the surface and the inside of the concrete – if it goes beyond 35°F, it might lead to cracking. When removing insulation or protective measures, do it gradually to prevent thermal shock.

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Recommended concrete temperatures at the time of placement are shown below, in **Table 1.** The ready-mixed concrete producer has the ability to regulate the temperature of the concrete by heating the mix water and/or the aggregates. They can then supply concrete in compliance with the guidelines outlined in ASTM C 94.

Concrete temperature in cold weather should not surpass these recommended temperatures by more than 20°F. When concrete is at a higher temperature, it requires more mixing water, experiences a higher rate of slump loss, and becomes more prone to cracking. The act of placing concrete in cold weather offers the chance for superior quality, as a cooler initial concrete temperature generally leads to higher ultimate strength.

Table 1: Recommended Concrete Temperature at Time of Placement

Section Size, minimum dimension	Concrete Temperature as Placed
Less than 12 inches	55°F
12 – 36 inches	50°F
36 – 72 inches	45°F

The colder temperatures in winter typically result in a slower setting time and delayed strength gain for concrete. This, in turn, leads to postponed finishing operations and removal of forms. To counteract this, chemical admixtures and adjustments to the concrete mixture can be employed to hasten the setting time and strength gain. In winter, accelerating chemical admixtures, which adhere to ASTM C 494—Types C (accelerating) and E (water-reducing and accelerating), are commonly utilized.

While calcium chloride serves as a common and effective accelerating admixture, it should not exceed a maximum dosage of 2% by weight of cement. For prestressed concrete or situations where corrosion of steel reinforcement or metal in contact with concrete is a concern, non-chloride, non-corrosive accelerators are recommended. It's important to note that while accelerating admixtures speed up the setting and strength gain, they do not prevent concrete from freezing, and their use does not exempt the requirements for concrete temperature, appropriate curing, and protection from freezing.

To accelerate the setting time and strength gain of the concrete, it is possible to increase the quantity of Portland cement or opt for a Type III cement known for its high early strength. In cold weather, it might be feasible to decrease the relative percentage of fly ash or ground slag in the cementitious material component, although this adjustment might pose challenges if the mixture was originally designed for durability. The optimal decision should seek a cost-effective solution while mitigating the effects on the final properties of the concrete.

Concrete should be placed with the lowest practical slump to minimize bleeding and setting time. The addition of 1 to 2 gallons of water per cubic yard will extend the setting time by ½ to 2 hours. Prolonged setting times will extend the bleeding duration. Do not initiate finishing operations while the concrete is still bleeding, as it will result in a compromised and weakened surface.

Before pouring concrete, it's crucial to make adequate preparations. Ensure that snow, ice, and frost are cleared, and that the temperature of surfaces and metallic embedments in contact with concrete is above freezing. This may involve insulating or heating subgrades and contact surfaces before placement.

Have all the necessary materials and equipment ready to safeguard the concrete during and after placement, preventing early-age freezing and retaining the heat generated by cement hydration. Common measures include using insulated blankets, tarps, and straw covered with plastic sheets. Depending on ambient conditions, additional protection may require enclosures and insulated forms. Pay special attention to corners and edges, as they are particularly susceptible to heat loss.

For safety reasons, fossil-fueled heaters in enclosed spaces should be vented. This venting also helps prevent the carbonation of newly placed concrete surfaces, which can lead to dusting.

To prevent plastic shrinkage cracks, it's essential to avoid allowing the concrete surface to dry out while it's still in a plastic state. Subsequently, proper curing of the concrete is crucial. Avoid water curing when freezing temperatures are anticipated, and instead opt for membrane-forming curing compounds or impervious paper and plastic sheets for concrete slabs.

Forming materials, excluding metals, play a crucial role in retaining and evenly distributing heat, offering sufficient protection in moderately cold weather. In extremely cold temperatures, it is advisable to utilize insulating blankets or insulated forms, particularly for thin sections. The removal of forms should be delayed for a period ranging from 1 to 7 days, taking into account the setting characteristics, ambient conditions, and anticipated structural loading. To assess the in-place concrete strength before removing forms or applying loads, either field-cured cylinders or nondestructive methods should be employed. It's important to note that field-cured cylinders are not suitable for quality assurance purposes.

Extra attention is essential when dealing with concrete test specimens used for accepting concrete. Cylinders should be stored in insulated boxes, possibly equipped with temperature controls, to ensure they are cured within the range of 60°F to 80°F for the initial 24 to 48 hours. It is recommended to place a minimum/maximum thermometer in the curing box to keep a temperature record.