Cold Weather Concrete Tips

WHAT IS COLD WEATHER CONCRETING?

According to the American Concrete Institute (ACI), cold weather is defined as a period when for more than 3 consecutive days the average daily temperature is less than 5^{0}C and the air temperature is not more than 10^{0}C for more than one-half of any 24-hour period.

Canadian Standards Association (CSA) A23.1-14 Clause 7.1.2.1 states: “When there is a probability of the air temperature falling below 5°C within 24 h of placing concrete (as forecast by the nearest official meteorological office), all materials and equipment needed for adequate protection and curing shall be on hand and ready for use before concrete placement is started.” 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 understanding of the various factors that affect concrete properties.

In its fresh state, concrete freezes if its temperature falls below 4°C. The potential strength of frozen concrete can be reduced by more than 50% and it will not be durable. According to CSA A23.1-14 Note 2 to Clause 7.1.2.4 “When concrete reaches a compressive strength of 7 MPa, it normally has sufficient strength to resist early frost damage.” However, exterior concrete flatwork exposed to freeze-thaw cycling and de-icer salts must attain a strength of at least 32 MPa in order to ensure its long-term durability. CSA A23.1 mandates a curing regime of 7 days at a minimum temperature of 10^{0}C for concrete subject to these exposure conditions. Therefore, in cold weather some provision must be in place to ensure that this objective is met.

Concrete at a low temperature has a slower rate of set and strength gain. A rule of thumb is that a drop in concrete temperature of 10^{0}C will approximately double the set time. These factors should be accounted for when scheduling construction operations.

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 allowed to dry after completing the cure period before exposure to freeze-thaw cycling and de-icer salt exposure.

The reaction between cement and water called hydration, generates heat. Insulating concrete retains heat and maintains favourable curing temperatures. Temperature differences between the surface and the interior of the concrete should be controlled. Thermal cracking may occur when the difference exceeds 20^{0}C. Insulation and protection should be gradually removed to avoid thermal shock.

HOW TO PLACE CONCRETE IN COLD WEATHER

Concreting in cold weather provides the opportunity for better quality concrete, as cooler initial concrete temperatures will typically result in higher ultimate strength and improved durability as long as proper curing is followed.

In cold weather, slower setting and rate of strength gain of concrete can delay finishing operations. Chemical admixtures and other materials can be used to help offset these effects. Accelerating admixtures conforming to ASTM C494 Type C (accelerating) and Type E (water reducing and accelerating) are commonly used.

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Accelerating admixtures can aid in preventing concrete from freezing but their use does not preclude the requirements for appropriate curing and protection from freezing.

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

Adequate preparation should be made prior to concrete placement. Have a pre-pour meeting and develop an action plan using these cold weather concreting guidelines:

- When the daily ambient temperature is 5°C or lower, extra precautions for curing should be followed to prevent damage from freezing and to maintain curing conditions that foster normal strength development.
- During cold weather, additional heat is often required to maintain favorable curing temperatures of 10°C to 20°C. However, care must be taken to not exceed the recommended concrete temperature to avoid loss of moisture from the concrete.
- Upon concrete finishing, it is important to cover 100% of the exposed concrete surface by using insulated blankets and tarping. Leaving formwork in place for vertical elements (walls, columns, etc.) will help in mitigating damage from freezing. The top surface of such formwork must be protected as well in order to prevent damage from freezing.
- Temperature differentials (mainly rapid temperature changes) like freezing and thawing can be detrimental to the strength and durability of the concrete often causing damage to the surface, resulting in scaling or delamination.
- Chloride infiltration from de-icing chemicals can cause damage to the surface of concrete resulting in spalling. We strongly recommend that de-icing chemicals, or salt of any kind, not be used in the first year of concrete placed, especially slab-on-grade (driveways, sidewalks, etc.).
- Sealing compounds (sealers) applied to the surface of hardened concrete can help to reduce the penetration of liquids such as water, de-icing solutions that cause freeze-thaw damage and chemical attack. Application of a sealing compound is highly recommended. See manufacturer's instructions prior to application.

It is the owners right, at their own expense, to conduct concrete testing for product quality and ensure that the concrete placed meets the requirements of the project design. The owner shall be responsible for reviewing all test reports to ensure the project requirements are met.

It should be noted that the aforementioned practices and procedures are suggested recommendations for concrete used for general purpose. The user should consider the primary intent of these recommendations and use judgment in deciding what is adequate for each particular circumstance. Always default to contract documents or project specifications under the direction of the engineering company on record.

For comprehensive concreting guidelines, please refer to the Canadian Standards Association (CSA), A23.1.21 Curing and Protection or American Concrete Institute (ACI), Standard 305, 306 & 308 for additional concrete curing procedures.

References:
1. Cold Weather Concreting, ACI 306R, American Concrete Institute, Farmington Hills, MI
2. Design and Control of Concrete Mixtures, 8th Edition 2011, Cement Association of Cana-da, Ottawa Ontario.
3. CSA A23.1-14 Concrete Materials and Methods of Concrete Construction, The CSA Group, Mississauga ON Canada.
4. CSA A23.2-3C-14, Making and Curing Concrete Compression and Flexural Test Specimens, The CSA Group, Mississauga, ON Canada.
5.Cold-Weather Finishing, Concrete Construction, November 1993.
6.CIP-27 Cold Weather Concreting, NRMCA with permission, Silver Spring, MD, www.nrmca.org
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