Concrete temperature monitoring becomes more critical in cold weather as low temperatures decrease the rate of strength development during curing. If there is a large difference between the temperature of the in-situ concrete and ambient air temperature, strength and durability are jeopardized.

How Do Thermal Cracks Form?

Thermal cracking occurs when the tensile stress of the concrete exceeds its tensile strength. In more basic terms, differences in temperature between the concrete core and the surface of the concrete structure lead to thermal cracks. Additionally, as cement mixes with water, a chemical reaction called hydration occurs, generating heat. In this process, the heat is trapped inside the core and cannot escape quickly enough. As a result, the core continues to get warmer while the surface cools.

Why Is Thermal Cracking a Problem?

Cracking increases the permeability of the structure, making it easier for water, air, and chloride to penetrate the concrete. Cracking also results in rebar corrosion and, in severe cases, reduces the durability and integrity of the entire concrete structure. It is therefore essential to monitor concrete mix temperature, ambient temperature, and differential temperature and to adjust appropriately to avoid thermal cracking.

Preventative measures must be taken in order to minimize various types of cracking associated with the heat generated by the hydration of cement such as random map cracks, vertical cracks in walls (especially in the base of the wall), and uniformly spaced cracked in beams.

How to Control Concrete Temperature in Cold Weather

To ensure proper strength gain in structures during construction in winter, new concrete
placements are generally protected from the cold weather using an external source of heat. In mass concrete placements, for example, protective blankets are often used to cover the concrete and distribute the heat generated from the concrete itself to decrease the temperature difference between the surface and core.

Read About the 7 Cold Weather Concreting Mistakes! Here!

Tips for Controlling Concrete Temperature in Cold Weather

1. Optimize Your Concrete Mix: Using low-heat cement; aggregate substitutes such as fly ash, limestone, or slag; and low water-to-cementitious materials are all good ways to optimize your concrete mix.
2. Use Insulation: This allow you to control temperature differentials between the core and the surface.
3. Cool Concrete Before Placement: This can be done using chilled water, chipped or shaved ice, or liquid nitrogen.
4. Cool Concrete After Placement: Using embedded non-corrosive cooling pipes prior to concrete placement. This removes heat by circulating cool water from a nearby source.

However, in order for these measures to make a valuable difference, you must be able to monitor and report on the changing temperatures of your concrete structure.

Traditionally wired systems, such as thermocouples and loggers, are used to monitor concrete temperature. In most of these systems, however, wires stick out from the concrete and need to be protected from on-site damage. The data loggers that are attached to the ends of thermocouples may also experience malfunctioning at very low temperatures. Moreover, the manual installation process for these types of sensors, along with the time-consuming data collection process, become more difficult in cold weather conditions. More specifically, when heat blankets are used, it is a challenge to lift them and find the end of the temperature cables.

SmartRock: Wireless Concrete Temperature Sensor
Curing concrete in cold weather is costly due to equipment rentals, such as blankets and heating elements, as well as the labor required to operate these heating systems. Investing in a product like SmartRock, a wireless concrete temperature and strength/maturity sensor, can save significant time and money on a project.

These wireless sensors are embedded in the formwork (on the rebar) of the concrete structure. They provide real-time analysis of temperature and strength during all stages of the curing process, from early-age to hardening, at regular 15-minute intervals. These measurements upload directly on your free SmartRock app (available for both iOS and Android devices), where they can be downloaded and shared with team members. From there, you can view the minimum and maximum temperature values and track the temperature history.

One of the biggest advantages of SmartRock is that it is completely wireless. This means you no longer need a separate costly data logger. Furthermore, you don’t have to worry about tripping over messy wires, accidentally cutting the wrong wire, or damaging the sensors on-site.

See How Graham Construction Reduced Labor Costs By 85% with SmartRock Wireless Sensors Here
SmartRock’s ability to monitor the effects of the in-situ concrete and ambient temperatures makes it easier to control concrete curing and ensure optimal conditions. Equipped with real-time results, contractors can optimize the heating process, decrease energy costs, and save time in their project schedule by knowing when to move on to subsequent construction operations such as formwork removal or post-tensioning. In addition, SmartRock sensors can be used to estimate the in-place strength of concrete based on the maturity method, according to ASTM C1074.

Learn More About the Maturity Method Here

**Editor’s Note: This post was originally published On October 24, 2016 and has been updated for accuracy and comprehensiveness.**