SPEAKING IN CODE

The Low Down *on* Testing *and* Special Inspection Topics December 2020

Special Reissue Edition

C-C-C-COLD WEATHER CONCRETING

Polar vortex or not, you knew it was going to get cold again, right? F&R is pleased to have the opportunity to share the following article on issues with cold weather concrete courtesy of someone who would know - Robert Neal, Technical Services Engineer with Lehigh Cement in Richmond, Virginia. We find this piece to be not only timely, but also super informative and easy to understand for the layperson.

At least for now, cold weather happens every year for those of us in the mid-Atlantic. And when it does, your concrete acts crazy. Be prepared for the challenge by spending a few moments by a toasty fire reading the sage words of Bob Neal.

Cold weather is good for many things, such as skiing and making snowmen with the kids. But it's a lousy time to work with concrete. Cold weather concrete construction presents a whole new set of challenges to both the concrete producer and contractor.

To address these challenges we must first drill down to the root cause of cold weather concreting problems. In doing so we find that it is not so much the physical/chemical phenomena within the concrete itself that cause the problems, but rather the recurring psychological problems that people have towards cold weather construction—amnesia and denial.

As long as I can remember we have had cold weather each year—that's no surprise to anyone. But why is it then that every winter, as temperatures drop, I get a phone call from someone wanting to know what's wrong with their concrete? It set too slowly or it didn't gain enough early strength or the surface is mysteriously popping off. When they say "this has never happened before in the 20-plus years I've worked with concrete," you know you are dealing with someone who is suffering from an acute case of amnesia or is in outright denial. The fact is that this has indeed happened before and will probably happen again unless we take a different approach-cold weather concreting problems are people problems, not concrete problems.

To overcome these psychological ailments, we first must accept these simple truths:

1. The setting and strength gain of portland cement is the result of a chemical reaction known as hydration.
2. Heat is a catalyst to the hydration reaction—the more heat the faster the reaction, less heat the slower the reaction.
3. Concrete is a cold-blooded animal—it's body temperature rises and falls in direct harmony with its surroundings. At about 55 degrees its activity becomes sluggish and below about 40 degrees the concrete simply goes to sleep and hibernates, awaiting the return of spring. In extreme cases, our concrete beast can freeze to death.

There are many potential problems with concrete that are caused by cold weather, but let's look at a classic example—the inability to resist early-age freezing and freeze-thaw cycles. All too often I'm called upon to console a very dissatisfied owner and a rather perplexed contractor, who are trying to figure out what kind of disease their concrete has contracted. The top surface is mysteriously popping off in little pieces the size of a quarter. Is it chicken pox or leprosy? Neither--it's frostbite! The concrete was exposed to freezing or to freeze-thaw cycles at a young and sensitive age.

To understand how this happened, consider the requirements for concrete that will be exposed to freezing and to freeze-thaw cycles. According to ACI 306, Cold Weather Concreting, concrete must reach at least 500 psi compressive strength before being exposed to its first freeze. Is this a new requirement? No, we've been saying this for many years. ACI 306 also states that concrete should attain 3500 psi compressive strength before being exposed to freezing and thawing cycles. Another new concept? Again, No! Then why does it seem that after cold weather has arrived everyone continues to specify and order the same standard 3000 psi design strength mix they used all spring and summer? They should know that a 3000 psi design strength concrete is just that—designed to achieve 3000 psi (plus some overdesign) at 28 days when cured at 73 degrees. Do they really intend to keep their concrete at 73 degrees for a month? Probably not! Then how do they expect the concrete to gain strength to 3500 psi before the concrete is exposed to freeze-thaw cycles? It shouldn't be a big surprise when the concrete scales.

It's not that 3000 psi design strength concrete is a bad mix and it's not the concrete's fault that the surface scaled, but it wasn't the right mix to use under these conditions. If the concrete needs a compressive strength of 3500 psi before exposure to freezing and thawing cycles, then specify and order a mix that will achieve this strength within the time frame that the concrete will be protected in the field.

Is There Hope?

Of course! There are a number of ways to deal with cold weather concrete construction both from production and construction standpoints. These aren't new or revolutionary ideas—they've been known for decades. A very brief review follows, to aid those suffering from temporary amnesia.

Heat the concrete: By using heated mix water, and in some cases heated aggregates, the concrete can be produced at a temperature sufficient to jump start the hydration reaction so that concrete can set and gain enough strength to get through the critical first few hours.

Increase cement content: Heat of hydration in concrete is due to the exothermic (heat producing) nature of the hydration reaction. The amount of heat generated is dependent on the quantity of cement: the more cement the more heat. A higher grade of concrete (more cement) can therefore be used to respond to colder conditions.

Use high-early-strength (Type III) cement: Type III cements have a higher rate of hydration and therefore a higher rate and amount of heat generated, as well as an increased rate of strength gain.

Use accelerators: Accelerators increase the rate of hydration, which means that more heat is generated in the early stages and the concrete sets faster. But remember that accelerators do not prevent freezing or frost damage. Retain the concrete's body temperature: By insulating the forms or covering the concrete with adequate insulation, heat can be retained in the concrete and sustain the hydration reaction so that the concrete can achieve adequate strength.

Provide an incubator: The temperature of the concrete is related to the temperature of its surroundings. Therefore, we can create an artificial environment for the concrete - as long as the concrete is nice and warm, it doesn't really care if the outside temperature is 10 below.

These are some of the more obvious precautions that can be taken to offset the effects of cold weather on concrete. Concrete mixes and admixtures are under development that will provide new weapons to combat cold weather concrete problems. But the key is that cold weather concreting must be a **TEAM** effort. In cold weather, concrete cannot simply be **PLACED, FINISHED, AND FORGOTTEN**—it needs continuing warmth and care during its infancy.

Be aware that there are potential side effects from some of the methods used to cope with cold weather. For instance, when heating an enclosed area, be sure to use heaters that are vented to the outside. The burning of fossil fuels produces carbon dioxide which can combine with moisture in the air and on the surface of the concrete to produce carbonic acid. The carbonic acid reacts with the calcium hydroxide in the fresh concrete leading to a soft, dusty surface when the concrete hardens. Vented heaters will prevent this problem.

Calcium chloride is an excellent accelerator but can lead to a dark discoloration of the surface of the flatwork. This is more common on troweled or hard-troweled surfaces and typically appears in a random pattern, almost like the coloring of a pinto pony, hence the term “pinto concrete.” In severe cases, the discoloration can cover the entire slab surface.

So if you ask, *“What’s new in cold weather concreting?”* the answer is simple--NOTHING! Cold weather comes, cold weather goes, and eventually cold weather comes again. We’ll face the same problems over and over until we overcome the amnesia and denial that too many people have towards cold weather concreting. The next time you encounter a problem with concrete in cold weather, don’t blame the concrete! People decide what mix to use and what level of protection (or lack thereof) to provide for the concrete. Concrete cannot control its own destiny—only people can.

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