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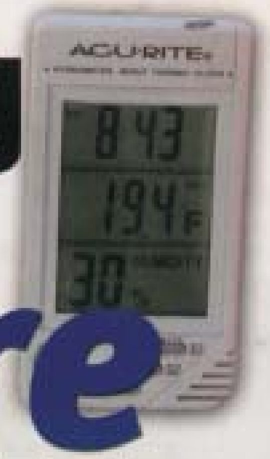
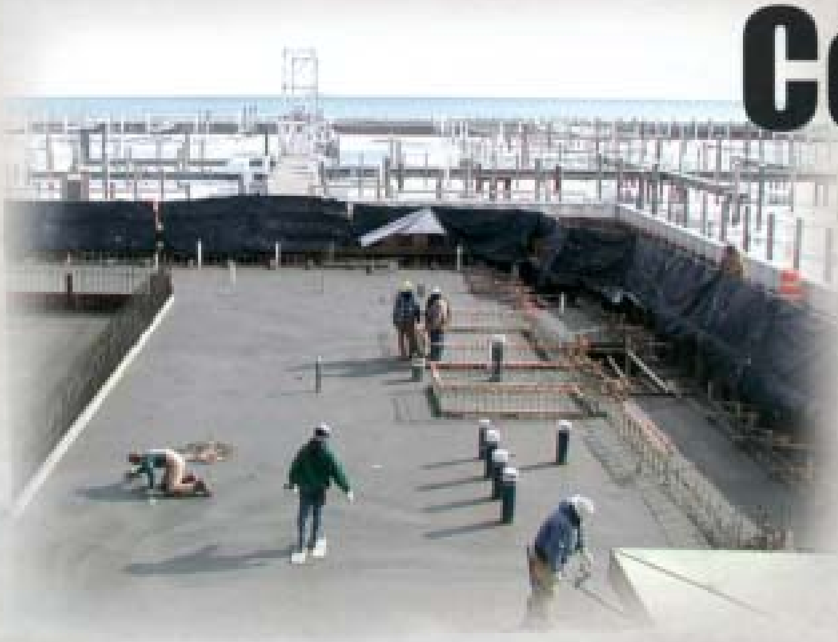
Concreting Under *Severe* Conditions





If the Show Must Go On

Freeze-resistant concrete—Is it possible? Is it cost effective?

BY WARREN E. MCPHERSON, JR.

To most connoisseurs of concrete, depending on their perspectives, the answer to at least one of the above questions is probably no. Theorists might think freeze-resistant concrete is not possible. If you are a contractor, you probably feel that there is no way freeze-resistant concrete can be cost effective. And workers that are in the trenches placing the concrete know that concrete will not get hard if placed when the outside temperature is below 32°F (0°C).

Now that we have all decided that it is not possible and not cost-effective, let's continue with the article! This article is presented not through the eyes of a scientist, but rather through those of a practitioner in the industry. Experts say that concrete strength must reach 500 psi (4 MPa) to resist one freezing-and-thawing cycle. Based on my many years of experience working with freeze-resistant concrete, I feel that something else besides strength must contribute to a mixture's freezing resistance. The key is having the right circumstances, the right nonchloride accelerator, and above all, the right team.

WHY NOT WAIT UNTIL SUMMER?

Obviously, there must be a need to place concrete in a cold environment, either because of the ambient temperature, or an internal source of cold (such as a cold-storage freezer) to consider freeze-resistant concrete. Such was the case with Pfizer Pharmaceuticals in Ann Arbor, MI. Ongoing expansion at their Ann Arbor Research Campus and their schedule required that the powerhouse be completed in the early stages of construction. It was the middle of winter but the schedule dictated that "the show must go on."

The contractor, Aristeo Construction from Livonia, MI, and their superintendent, Dave Curtis, chose freeze-resistant concrete as a viable alternative to building a temporary structure, providing heat, and maintaining 50°F (10°C) for 3 to 7 days, as prescribed by ACI 306. On one particular day, the ambient temperature was 8°F (–13°C) when concrete placement began at 8 a.m. It snowed until noon. The high for the day was 22°F (–6°C). Workers hard-trowel finished the slab by 2 p.m. and, before dark, placed blankets on the slab to protect the surface from the ingress of moisture (snow and sleet). That concrete would not, and did not, freeze. The show went on as scheduled.

A few years ago, I was involved with an exterior placement of concrete at a fast food restaurant in late December. Everything was done except for the sidewalks around the building. The owner, who happened to be an independent franchisee, had several options, but only one was realistic:

1. Not opening;
2. Placing plywood down and hoping that no one slipped or fell and got hurt;
3. Placing conventional concrete, knowing that it would have to be replaced in the spring, disrupting business; or
4. Pay a \$25 to \$30/yd^3 premium for 18 yd^3 (14 m^3) of freeze-resistant concrete.

The answer to this owner's dilemma was obvious. Twenty-five dollars per cubic yard was a small price to pay to get the cash registers ringing.

Cold-storage facilities, from time to time, need their floors replaced for a number of reasons. Rather than shutting down the freezer and breaking out the concrete, many times, owners can place a new concrete floor over an existing one—freeze-resistant concrete makes this possible.

After giving a presentation on cold-weather concreting to 60 of Aristeo Construction's field super-intendents, project managers, and estimators last fall, superintendent Gary Seibert came to me and said that he was extremely worried about an upcoming placement at Greenfield Village that would occur in December or January. (Greenfield Village is a part of the Henry Ford in Dearborn, MI.) They had to form and place a structure with a U-shaped wall configuration with archways on each wall (Fig. 1). This structure was to become the new entryway to Greenfield Village. Because of the height of the structure, and the lack of access to vibrate the concrete properly, a 7 to 8 in. (175 to 200 mm) slump concrete was needed. Seibert thought there was no realistic way to protect the concrete from freezing. My answer to him was freeze-resistant concrete.

THE NEED TO PROCEED

On February 5, 2003, when most contractors were at the World of Concrete in Las Vegas, I was staffing my station at 5 a.m. at the prestigious Grosse Pointe Yacht Club in Grosse Pointe, MI, beginning a 1260 yd^3 (960 m^3) freeze-resistant concrete placement. The ambient temperature was 15°F (–9°C), with wind gusts up to 20 mph (9 m/s). It would only reach a high for the day of 22°F (–6°C). The Grosse Pointe Yacht Club is on Lake St. Clair, which connects Lake Huron to the Detroit River, and ultimately to Lake Erie.

The owner retained Aristeo Construction to replace the aging swimming pool at the yacht club, which sat at the edge of Lake St. Clair. The project could not start until the official end of summer in Michigan—Labor Day 2002. A barge was sunk and used as a bridge along the north side of the clubhouse to allow passage to the pool. Demolition of the old pool came first, with constant dewatering to follow.

Fig. 1: Archway that was to become the new entryway to Greenfield Village (part of the Henry Ford in Dearborn, MI). Freeze-resistant concrete allowed placement in the middle of winter while maintaining a 7 in. (175 mm) slump

Unfortunately, winter came early and it lingered. The 140 x 150 ft (43 x 46 m) base for the pool was 22 to 24 in. (560 to 610 mm) thick and had to be placed before anything else could proceed. Representatives from the contractor, the concrete supplier, the engineer, the owner's representative, and I discussed several options at a preplacement meeting. Obviously, if the cost of using freeze-resistant concrete could be avoided, that would be the owner's first choice. We discussed the use of nonchloride accelerators at normal dosage rates of 10 to 30 oz./cwt (0.7 to 2.0 L/100 kg). Because the 140 x 150 ft (43 x 46 m) floor would become the working platform for forming and placing the walls for the pools and tunnels, there was no realistic way to protect the concrete after initial curing. For this reason, we agreed that the concrete should be 4000 psi (28 MPa) and air-entrained to protect it from subsequent freezing-and-thawing cycles.

The actual 60 x 80 ft (18 x 24 m) eight-lane pool bottom and the 20 x 45 ft (6 x 14 m) training pool only received a broom finish to ready them for a subsequent finishing treatment, but the concrete around the pool bottoms had to be hard-trowel finished because eventually it would become the floor for tunnels surrounding the pools. Hard-troweling air-entrained concrete was a concern to all, but the need to protect the hardened concrete from freezing and thawing outweighed the risk of prematurely sealing bleed water below the surface. It was agreed that the finishers would take extra care not to trap any bleed water.

Because I am an examiner for the ACI Flatwork Finishers Certification Program, the contractor asked that I be present to assist the finishers. I pointed out that if freeze-resistant concrete was used, potentially trapping bleed water would not be an issue; there is no bleed water with freeze-resistant concrete. Temperatures continued to remain between 10 to 20°F (–12 to –7°C), never reaching 32°F (0°C).

With the need to proceed, and the long-range weather forecast not encouraging, the owner decided to schedule the placement and use freeze-resistant concrete. The typical dosage rate for the nonchloride accelerator used is 60 to 90 oz./cwt (3.9 to 5.9 L/100 kg) to produce freeze-resistant concrete. There were several factors that helped determine the dosage rate. First, we considered the ambient temperature at the time of placement along with the temperature for the next 24 to 48 h. The rate of placement and the distance the concrete was to be hauled also came into play.

Because of the space restraints, only one concrete pump was used. As previously mentioned, the sunken barge created a one-lane road, resulting in only one ready-mixed truck being able to come or go at a time. It was also determined that 150 to 200 yd^3 (115 to 150 m^3) would be preloaded. At 4 a.m. on the morning of the placement, I talked with Vic Muzzin, superintendent for the contractor, and Tim Mostoller, from the concrete supplier. With all the factors mentioned previously, we decided on a 40 oz./cwt (2.6 L/100 kg) dosage rate of nonchloride accelerator for the first 400 yd^3 (300 m^3). Because the floor was 22 to 24 in. (560 to 610 mm) thick, most of the first 400 yd^3 (300 m^3) of concrete would be buried and not subjected to the cold for very long.

After 400 yd^3 (300 m^3) had been placed and the lead finisher for the contractor. LeBaron Dixon, let me know that he was comfortable with the set of the concrete, we increased the dosage rate to 50 oz./cwt (3.3 L/100 kg), and at 800 yd^3 (600 m^3) to 60 oz./cwt (3.9 L/100 kg). Within 2 h of placement, two finishers using machines with float blades were on the concrete. Within 4 h of initial placement, two finishers on knee boards were putting a hard-troweled finish on the tunnel floor areas that had been previously floated (Fig. 2). Workers covered the placement with visqueen and then with insulated blankets, for good measure.

On Friday, February 7, 2003, I peeled the blankets and visqueen back and used a surface thermometer to determine that the concrete surface temperature ranged from 30 to 72°F (16 to 22°C). On Monday, February 10, when the visqueen and blankets were removed, the concrete surface temperature was still 55 to 60°F (13 to 16°C). The ambient temperature never got above 25°F (–4°C) during this 5-day period.

CHOOSING WISELY

Not all nonchloride accelerators can produce freeze-resistant concrete. For example, our company has four nonchloride accelerators, but only one offers the freeze-resistant capability. Make sure your admixture supplier has a product capable of making freeze-resistant concrete, and that they have experience using it. The construction team must have complete confidence in their admixture supplier at all times, but especially when dealing with freeze-resistant concrete.

There is a cost associated with making freeze-resistant concrete, but when you consider the true cost of protecting concrete as outlined in ACI 306, the "cost" may actually turn into a "savings." Freeze-resistant concrete can be a vital, cost-effective tool if the situation dictates that "the show must go on!"

Selected for reader interest by the editors.

Fig. 2: Placing concrete in February at the Grosse Pointe Yacht Club in Grosse Pointe, MI. Within 2 h of placement, two finishers using machines with float blades were on the concrete. Within 4 h of initial placement, two finishers on kneeboards were putting a hard-troweled finish on the tunnel floor areas that had been previously floated

The key to successful cold-weather concreting is having the right circumstances, the right nonchloride accelerator, and above all, the right team

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