Concrete Curing
Case Study

powerblanket®
patented technology

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Those in the concrete industry know that

cold weather can have detrimental effects on the concrete curing process. In the winter, concrete cures more slowly, unless of course, the fresh concrete is protected and perhaps heated externally to create an environment for the concrete to cure faster.

The question is, what's the best way to provide heat during the curing process? An independent test lab set out to learn just that, by comparing curing environments created with blankets from Powerblanket® and standard curing blankets. The blankets were put to the test in Wheeling, West Virginia on a concrete placement for the new tower being constructed for Wheeling Hospital.

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Background Information

Concrete hardens, gains strength, and attains desirable properties at a rate proportional to the temperature at which it is cured. The Cold Weather Concreting Committee (ACI 306) defines cold weather as “when the air temperature has fallen to, or is expected to fall below 40 °F (4.5 °C)”.

When the temperature reaches this point, concrete should be protected from freezing. Builders use a variety of methods—tents and heaters, heated blankets, or other methods—to continue constructing their projects during the winter.

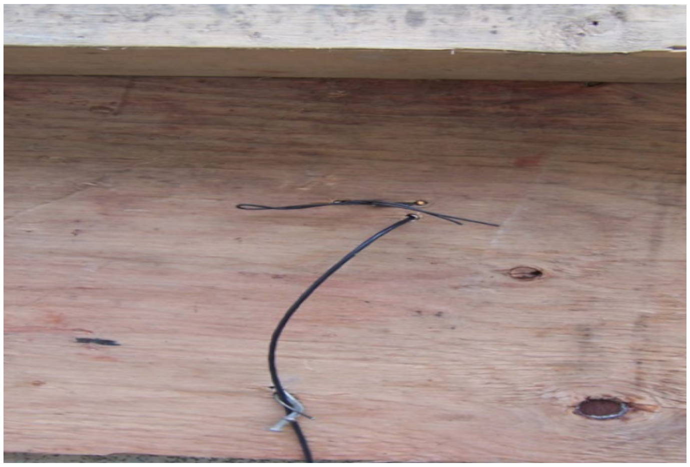
While protecting the fresh concrete, builders often use technology to measure the effectiveness of the protection and the actual curing rate of the concrete. The sooner the builder can remove the protection, the faster the project will be completed with a lower cost. Using an ASTM-standard testing method, builders are able to monitor the performance of their cold-weather protection and predict concrete strength.

Experimental Setup

The purpose of this experiment was to learn how concrete would cure underneath three different blanket types. The three types were (A) Powerblanket® Curing Blanket with the heat turned ON, (B) Powerblanket® Curing Blanket with the heat turned OFF, and (C) standard curing blankets.

To determine how each section of concrete cured, sensors were embedded inside the slab, the sensor lead was run to the outside of the formwork, and a digital datalogger was attached to each lead.

Closeup of sensor lead attached to reinforcing steel prior to placement.



Closeup showing the routing of sensor leads through the side forms

The concrete temperature was recorded over a period of approximately 72 hours. A sensor was also placed inside an extra test cylinder, which was then placed inside a heated cure box that was on site. For reference, ambient temperatures were recorded during the testing period.

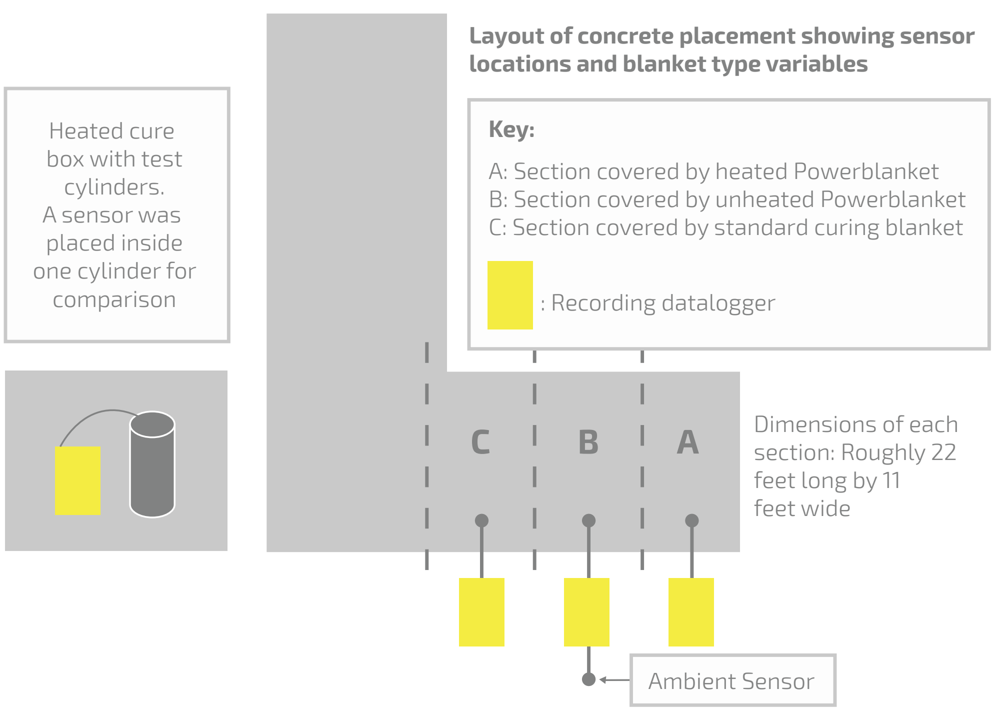
The Maturity Method (ASTM C1074) was used to estimate concrete strength over the course of the recording period, by utilizing a best-fit calibration curve generated by using the average of the past 36 sets of test cylinders from this project. This data provided an accurate estimate of the relative strength differences between the three sections of the slab.

Shot showing two of the three sections. The yellow dataloggers are visible.

Method

The temperature inside the concrete was sampled and recorded once every 10 minutes for a period of 72 hours. There were sensors placed inside each of the three sections of the slab, corresponding to the three variables: Powerblanket® heated, Powerblanket not heated, and standard blanket. Another sensor was placed inside a test cylinder and yet another measured ambient temperature at the jobsite.

The variables for this test were the three sections of concrete, each covered with a different type of curing regimen. Section A featured a Powerblanket curing blanket with the heat turned ON. Section B used a Powerblanket curing blanket with the heat turned OFF. Section C used a standard curing blanket.

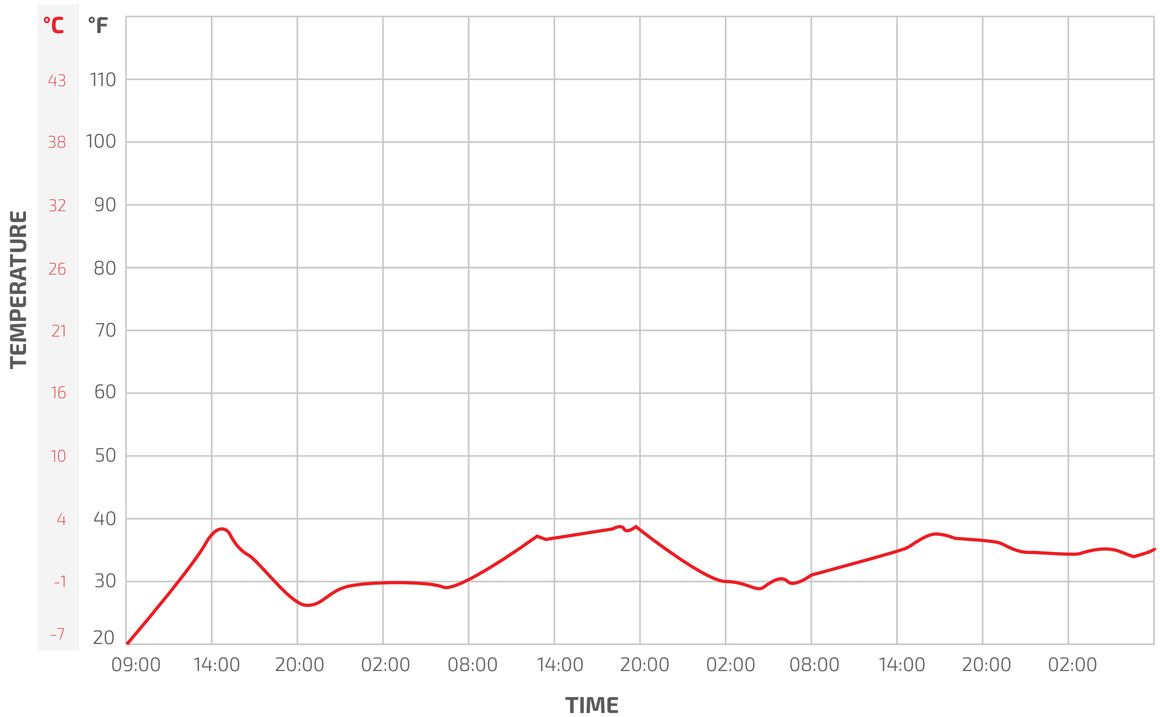


Layout of concrete placement showing sensor locations and blanket type variables

Temperature Results

Ambient conditions for this test were consistent with Cold Weather Concreting as defined by ACI 306.

Ambient Record 72 Hrs



Total Time:
2.9 days

Max Temp:
38.6 °F 3.6°C

Min Temp:
22.3 °F -5.4°C

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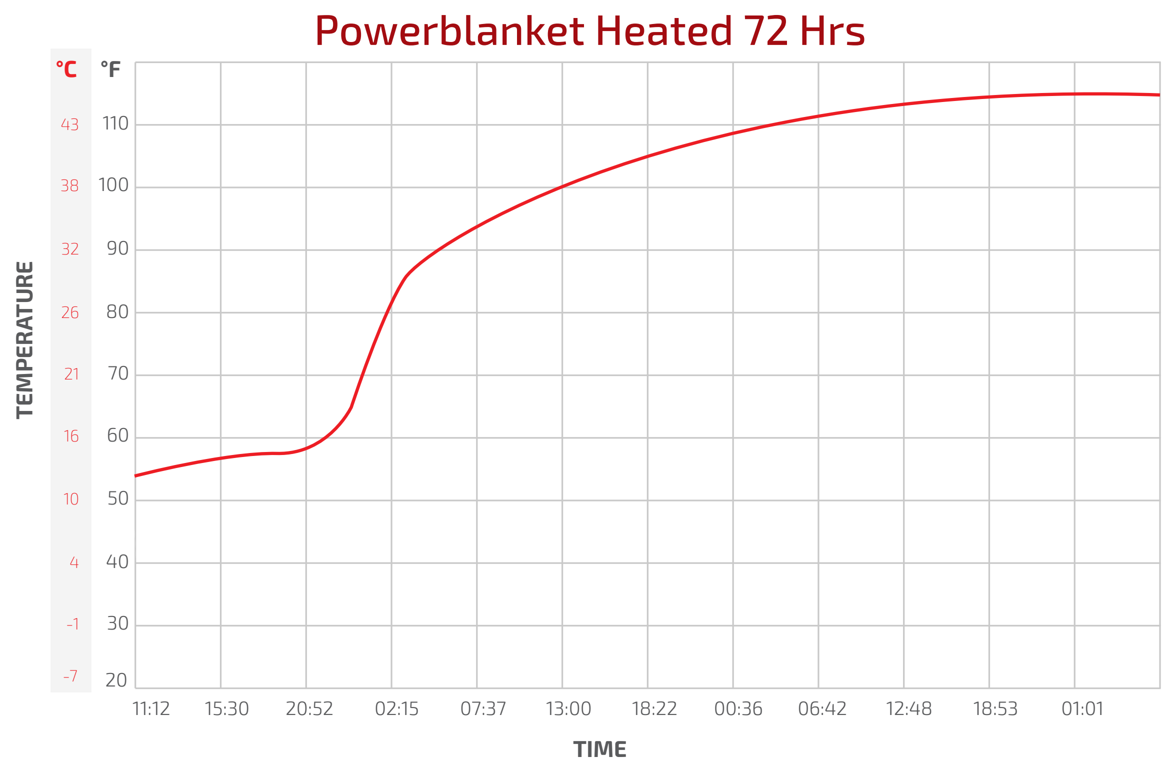
Section A: Heated Powerblanket

External heat was applied from above using a Powerblanket® heated curing blanket. Note gradual rise in temperature after heat was turned on at approximately 9:00 p.m. Heat was maintained above 100 ºF (38 ºC) for approximately 2 of the 3 days.



Total Time:
2.8 days
Max Temp:
115.1 °F 46.2 °C
Min Temp:
53.9 °F 12.2 °C

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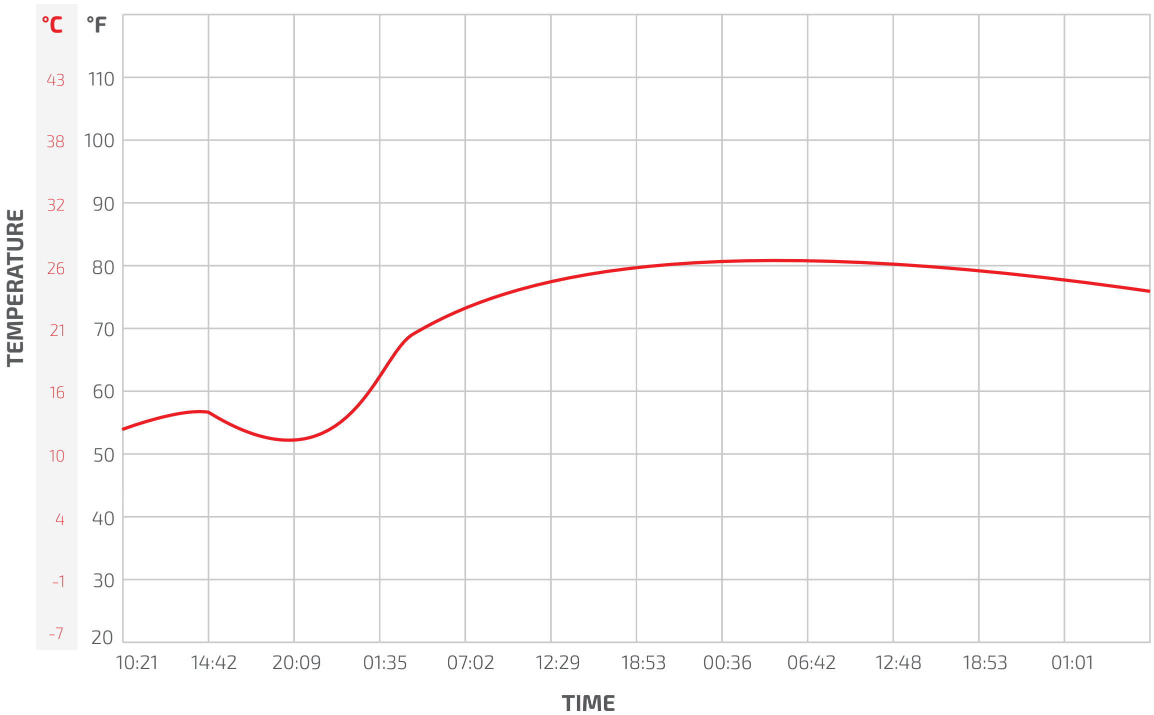
Section B: Unheated Powerblanket

A Powerblanket® concrete curing blanket was again used, but this time no external heat was applied. The maximum temperature attained was just over 80 ºF (26.5 ºC), simply due to the heat released by the concrete. The blanket did a good job of trapping the heat from the hydration reaction.

Powerblanket Unheated 72 Hrs

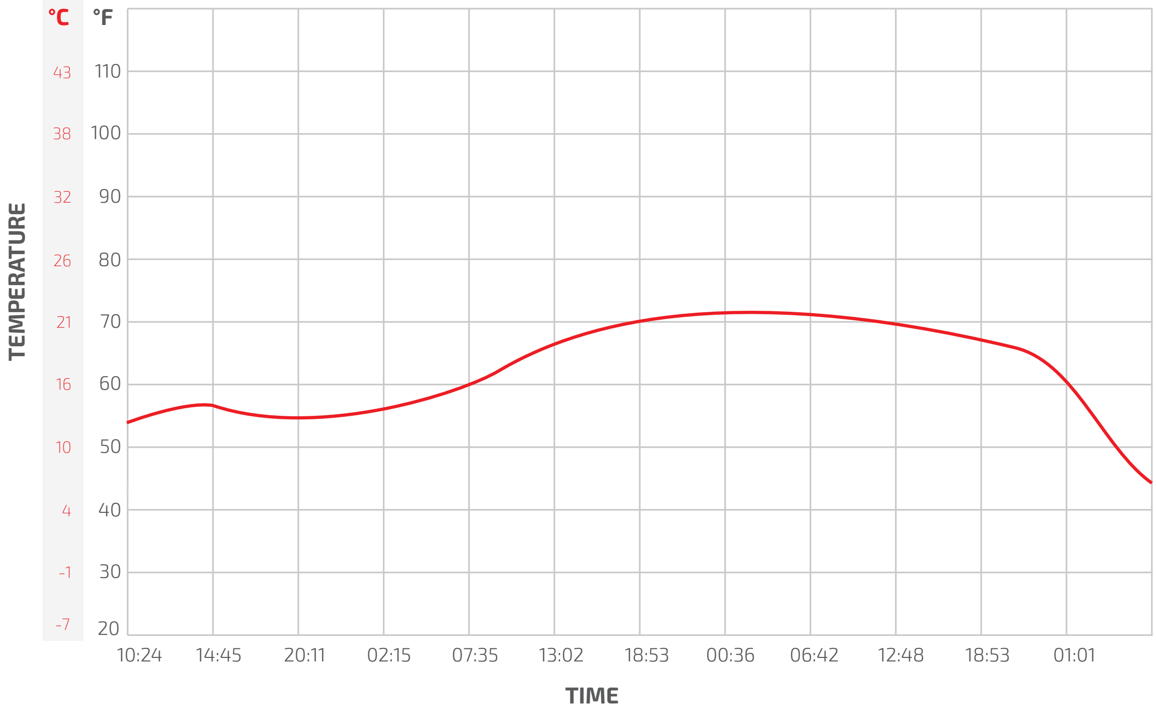


Total Time:
2.8 days
Max Temp:
82.3 °F 27.9 °C
Min Temp:
29.1 °F -1.6 °C

Section C: Standard Curing Blanket

This section used a standard construction insulating blanket and no external heat was applied. The temperature attained is consistently about 10 ºF (-12 ºC) lower than the adjacent section of concrete covered by the unheated Powerblanket® . Note that the temperature of the slab dropped noticeably over the last 8 hours of curing time, likely due to the cold rain that fell at the jobsite. Upon arrival at the jobsite at 6 a.m., it was observed that a portion of the standard blanket had been blown off part of the slab near where the sensor was located.

Standard Blanket 72 Hrs

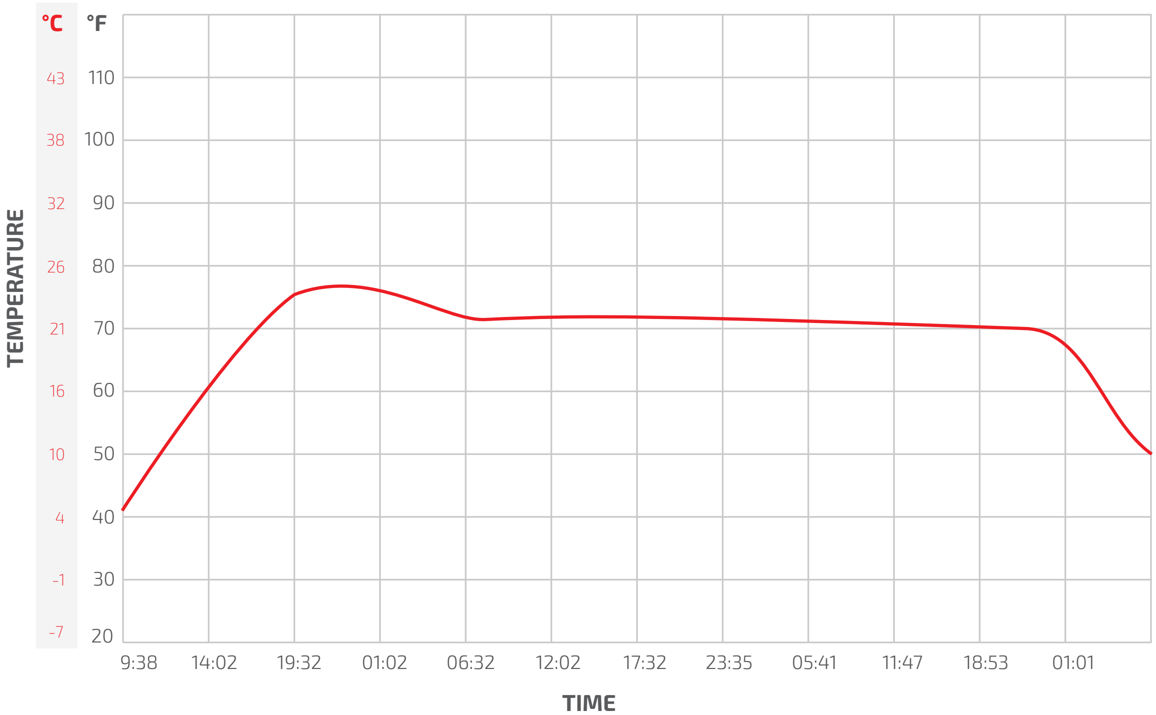


Total Time:
2.8 days
Max Temp:
82.3 °F 27.9 °C
Min Temp:
29.1 °F -1.6 °C

Test Cylinder

All the cylinders were placed in a heated cure box, but it should be noted that at some point in the evening of February 6th, it appears that the cure box heater malfunctioned. Upon arrival at the jobsite, it was observed that the cure box temperature was 50 ºF (10 ºC) as displayed by the high-low thermometer inside the cure box. The temperature of the cylinders reflects that drop in temperature.

Test Cylinder 72 Hrs



Total Time:
2.8 days
Max Temp:
75.5 °F 24.2 °C
Min Temp:
43.2 °F 6.2 °C

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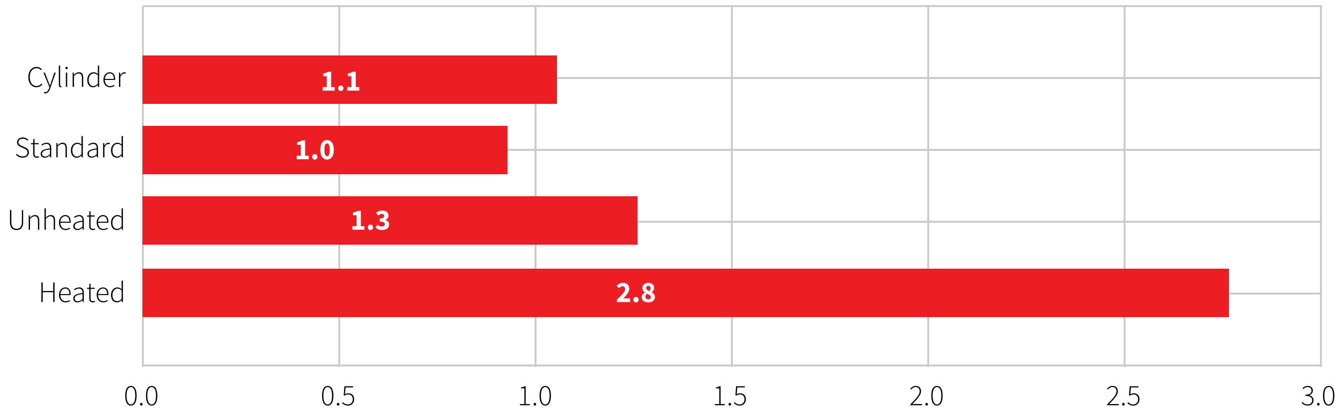
Strength Results

Each slab of concrete was cured for a period of 2.8 days, and the maturity at 2.8 days was compared to an equivalent age of laboratory curing. The equivalent age was how long it would take a slab to reach that level of maturity in a laboratory setting.

Section	Strength	Equivalent Age at 2.8 days
A. Heated Powerblanket	3,925 PSI	7.0 days
B. Unheated Powerblanket	2,642 PSI	3.3 days
B. Standard Blanket	2,162 PSI	2.5 days
Test Cylinder	2,415 PSI	2.9 days

Rate of Strength Gain Relative to Standard Blankets



Implications

It was established that the concrete under the heated blanket would cure significantly faster than the unheated concrete, and the heat-spreading technology contained inside the Powerblanket® heater would create a better curing environment than the industry-standard curing blankets. The task at hand was to measure the differences.

Heated Powerblanket

The heated Powerblanket accelerated the curing rate approximately 2.8 times more than the standard blanket (which, for the purposes of comparison, is being treated as the control). After just 3 days, the section of concrete heated by the Powerblanket attained the equivalent strength of a test cylinder cured under lab conditions for 7 days. By comparison, the concrete under the standard curing blanket attained the same strength as a cylinder cured for 2½ days. That correlates to a curing difference ratio of 7:2½, or a rate difference of 2.8 times.

Unheated Powerblanket

The unheated Powerblanket® section cured 1.3 times faster than the area under the standard blanket. When this rate of strength gain is projected over time, the unheated Powerblanket section will attain “design strength” (4000psi) in only 5¾ days. (This is determined by dividing the actual age at which design strength is attained in the laboratory by the “equivalent age-to-actual age ratio” at the moment. For this mix design, that is assumed to be 7.5 days based on historical data.) A similar determination can be made for all curing environments.

Standard Blanket

The standard blanket is compared to the other sections, but it can also be compared to test cylinders. In this case, the area under the standard blanket will reach 4000psi in 8.3 days, or more than 2½ days longer than the concrete under the unheated Powerblanket. Considering that zero energy was expended to attain this advantage, this should be a significant benefit to the contractor.

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Test Cylinder

For this test, the test cylinders were cured under mostly ideal laboratory conditions, but that would mean that they would attain higher strengths than the in-place concrete under the standard blankets. That difference would get even greater once the blankets are removed and the concrete equilibrates to ambient conditions after a few days. Higher cylinder vs. in-place strengths can lead to construction disasters, so caution is urged.

However, in this case, it is likely that the slab will attain sufficient strengths in the time required, and this particular slab was not elevated so there is little risk of collapse regardless. It is useful to always use common sense when relying entirely on test cylinders for early-age strength estimates. Better still, utilizing an in-situ monitoring system would allow direct comparisons between the strengths of all areas and sample types.

Conclusion

Powerblanket® cures concrete 2.8 times faster than conventional insulated blankets, and produced a cold weather concreting strength of 3,925 in 72 hours. Powerblanket allowed the work to get done faster and the concrete to become stronger, reducing the amount of downtime and lost profits due to cold weather.

Don't let the elements get the best of you. Contact Powerblanket to get started on a heating solution for your business.

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