TCA Cylinder Curing Research

Many research hours have been spent documenting the ill effects of improper curing on the compressive strength on concrete acceptance cylinders, especially when the cylinders are subjected to dry and hot conditions. Despite this fact, countless concrete acceptance specimens are not initially cured as required by ASTM C31 (for normal strength concrete - control moisture loss and maintain temperature between 60°F-80°F). Although curing specimens submerged in water inside a thermostatically controlled curing box is most effective, these boxes are not used on the majority of projects due to cost and logistical reasons. The TCA wanted to take a look at various practical low-cost initial curing methods currently being used in hot summer conditions to see which ones seem to work and which ones do not, and hopefully to provide some guidance on effective cylinder curing methods.

In the preliminary round of testing concrete test cylinders were subjected to each of 7 different curing environments shown in Table 1. Curing containers (or exposed cylinders) were stored on a concrete sidewalk unshaded during the majority of the daytime hours. Four 4x8 inch concrete cylinders and a temperature logger were placed in each environment and temperatures recorded over the 48-hour initial curing duration. Water at approximately 64 degrees was placed in the containers just prior to concrete being mixed. Logging was started after the cast cylinders were placed in the test environment. The ambient temperature during the 48-hour initial cure period ranged from a low of 66°F to a high of 98°F. Although not the intent of the study, compression tests were performed on the cylinders after the curing study was complete.

The intent of this first round of testing was not to draw firm conclusions, but to help establish protocols for additional rounds of testing. The following observations were made:

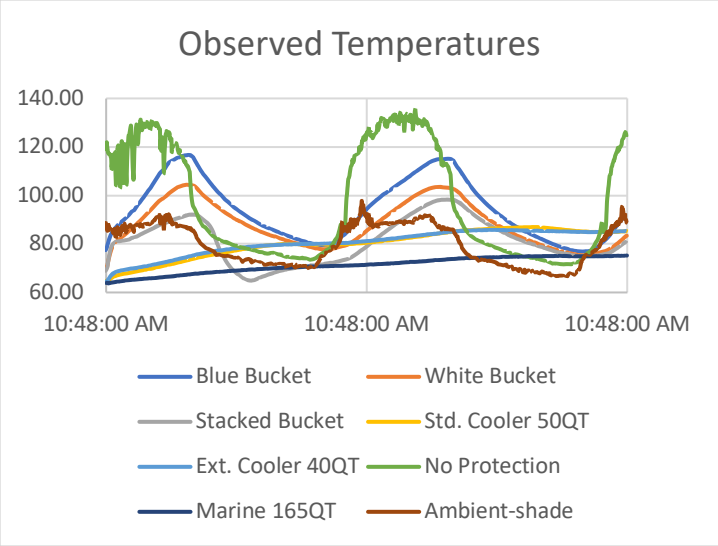
- Storing cylinders in 5-gallon buckets will likely not be an effective strategy, especially if stored in the sun.
- The white bucket was more effective than the blue bucket at reducing maximum temperature.
- The coolers tested were more effective at controlling maximum temperatures than buckets. The buckets were more affected by temperature fluctuations.
- A large volume of cool water in relation to cylinder volume can be effective at controlling maximum temperatures over a period of 48 hours or more. Lower volume coolers can be effective when shorter initial curing times are expected.
- The additional benefit of an extended ice retention cooler may be offset by using a standard cooler of a slightly larger volume.
- Strategies using melting ice can reduce maximum temperatures, but also more complicated.
- As expected, controlled temperature, water- cured specimens were significantly stronger than unprotected cylinders.

Table 1 – Maximum Observed Concrete Temperatures

Curing Condition	Maximum Temperature over 48 Hours (°F)
No Protection	136
Blue 5-gallon bucket	117
White 5-gallon bucket	105
Stacked White 5-gallon buckets with ice*	98
Low cost standard cooler (50 QT)	87
Low cost extended ice retention cooler (40 QT)	86
Marine cooler (165 QT)	75
ASTM C31 requirement <6000 psi	***80***
ASTM C31 requirement >6000 psi	***78***

* For this condition the bottom container consisted of a white 5-gallon bucket with holes drilled in lid. A 2nd bucket was stacked on top with 20 lbs of ice inside. Holes were drilled in bottom of the top bucket so that cool water could fall into the bottom bucket as the ice melted.

Figure 1 – Curing Method Comparison



Takeaways for future research

1. Use all white containers.
2. Use a range of cooler volumes of similar insulating ability (perhaps 48, 70, and 94 QT).
3. Consider acclimating the water to desired temperature after the cylinders are placed into the containers.

Goals of Future Research

1. Develop a general rule of thumb estimate/relationship for the volume of water needed per volume of concrete to maintain acceptable maximum concrete temperature for a 48-hour duration in hot summer weather.
2. Provide recommendations on the feasibility of using melting ice or ice packs for smaller more economical coolers that cannot control maximum temperature over a 48-hour period using water alone.