Accelerated Curing of Precast Concrete Products

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Steam curing of precast, prestressed concrete beams. Photo: Henry G. Russell Inc.

Precast concrete products are typically produced on a 24-hour cycle to achieve the economy of production. For precast, prestressed products, this typically requires the use of accelerated curing to achieve the concrete compressive strength required at transfer of the prestressing force. Transfer is generally accomplished no later than 18 hours after the concrete is placed and may be achieved at 12 hours or less. In some situations, such as the use of high-strength concrete, the accelerated curing can be achieved by the internal heat of hydration. In most situations, however, it is necessary to utilize an external source of heat, such as steam or radiant heat, to achieve the necessary concrete strengths.

Curing Cycle

A curing cycle generally consists of four stages or time periods:

- Stage 1 – Initial set
- Stage 2 – Temperature gain
- Stage 3 – Constant temperature
- Stage 4 – Cool down

Application of heat should not begin until the concrete has achieved its initial set except to maintain a minimum temperature of 50°F inside the enclosure. The application of heat too early can be detrimental to subsequent strength gain. After initial set, the temperature rise must be controlled to prevent damage to the concrete. The American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Construction Specifications* limits the average temperature rise of the concrete to a maximum of 40°F per hour with a maximum concrete temperature of 160°F. A constant temperature, which can be less than 160°F, is then held until the desired concrete compressive strength, as measured on concrete cylinders cured with the beams or matched cured, is achieved. In the cool down period, the *AASHTO LRFD Bridge Construction Specifications* require that the cooling rate of the concrete not exceed 40°F per hour until a temperature of 20°F above the air temperature is reached. For precast, prestressed concrete, transfer of the prestressing force to the concrete should be accomplished immediately after the heat curing is discontinued. Otherwise, vertical cracks in the girders may result from thermal contraction.

For precast, prestressed products, achievement of the required concrete compressive strength for transfer means that the strands can be released and the product can be removed safely from the casting bed to the storage area. For this stage, handling stresses need to be carefully considered as described in the Precast/Prestressed Concrete Institute (PCI) *Bridge Design Manual*.[1]

The AASHTO *Standard Specifications for Highway Bridges* used to require steam- and heat-cured products that would be exposed to salt water to be kept wet for at least 7 days. Research has shown that moist curing of precast concrete products after a proper heat curing period does not improve the durability properties. Studies by Klieger[2] showed that an additional moist curing period following the accelerated curing cycle is not necessary and may be detrimental to the freezing and thawing durability of the concrete. The AASHTO requirement for 7 days wet curing was removed in 1992.

Benefits of Accelerated Curing

In addition to achieving the required concrete compressive strength at transfer more quickly, accelerated curing reduces the volume of permeable voids,[3] which improves freezing and thawing durability, reduces chloride permeability, and decreases absorption. Accelerated curing also decreases creep and shrinkage and, therefore, prestress losses. To quote a PCI Special Report:[4]

> "Historically, properly heat-cured concretes produced at low water-cement ratios have been found to have strength and frost resistance properties equal to or better than conventionally cured concretes."

Precast, Nonprestressed Products

The required concrete compressive strengths for precast, nonprestressed concrete products are generally lower than those required for precast, prestressed concrete products. Consequently, accelerated curing may or may not be used depending on the required strength and individual plant practices. When accelerated curing is used, it has the advantages mentioned previously and additional curing is not needed. When accelerated curing is not used, the durability properties will not be as good even though the same compressive strength may have been achieved. Consequently, additional wet curing is advantageous if durability is a concern. A longer curing period will produce a more durable concrete although there is a point of diminishing returns. This is generally taken as 5 to 7 days and is not considered as excessive. The use of curing compounds is not as beneficial as wet curing and can affect subsequent coatings and aesthetic appearance.

References

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