NATIONAL PRECAST CONCRETE ASSOCIATION

Curing Wet-Cast Precast Concrete

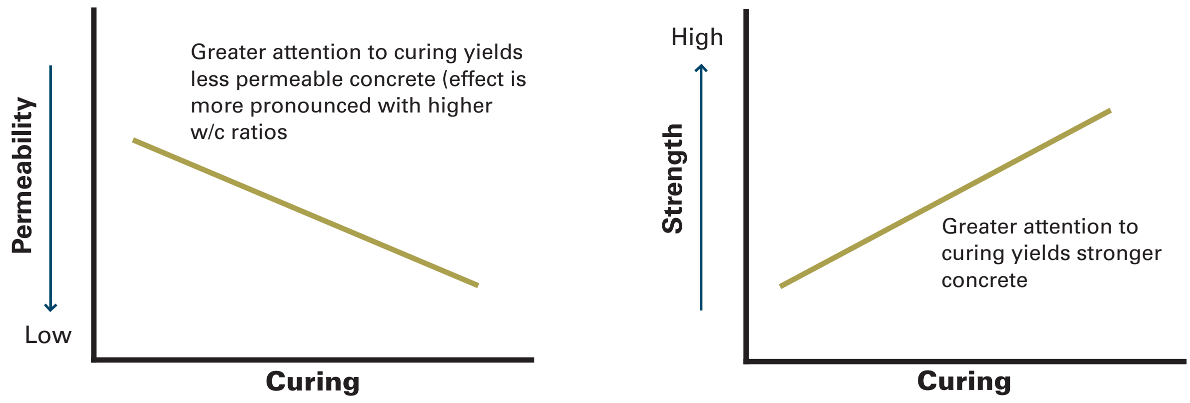
Tech Notes

All of the beneficial properties of precast concrete, including strength, durability and watertightness are enhanced through proper curing techniques. Unfortunately, the curing of precast concrete products is one of the last and perhaps most neglected steps in the manufacturing process, especially in a rapid production environment.

NPCA

Precast ... The Concrete Solution

Figure 1



Proper curing enhances impermeability and yields higher compressive strengths.

To support aggressive production schedules, most precast plants use greater cement content, admixtures or other methods to accelerate normal curing times. In addition, physical curing practices can also accelerate and enhance production by adhering to the two basic precepts of proper curing:

- Maintaining adequate moisture during the critical hydration period
- Maintaining a favorable temperature to promote full hydration. The lower the temperature, the lower the rate of hydration. However, there is an upper limit on the curing temperature.

Figure 1 illustrates the effect of curing practices on strength and permeability in wet-cast production.

Basic Principles

Simply stated, proper curing entails creating the optimum environment to promote the hardening or hydration of freshly cast concrete. Hydration is the chemical process that ultimately binds cement particles and aggregates into hardened concrete. Creating the optimum environment involves:

- Monitoring and controlling the temperature of the concrete and gradients (providing a favorable temperature [50 to 90 F] under conventional curing conditions and up to 140 F under low-pressure steam curing).
- Monitoring and controlling the humidity to limit moisture loss from the fresh concrete. The primary object of curing is to prevent or replenish the loss of necessary moisture during the early, relatively rapid stage of hydration.

Ambient temperatures are perhaps of greatest importance. Higher temperatures accelerate the hydration process. As a rule of thumb, a temperature increase of 18 F effectively doubles the hydration rate. However, an elevated temperature in a low humidity environment leads to the loss of needed water.

A primary goal of curing is to keep the concrete saturated. It is critical to provide the appropriate temperature and maintain a relative humidity of 80% in freshly placed concrete. Adequate curing is even more important when the water-cement ratio is low, since there is insufficient free water to provide a moist environment. The prevention of water loss helps ensure the strength of the concrete, leads to decreased permeability, less plastic shrinkage and avoids other undesirable factors.

During prolonged hydration, the cement in the mix develops into a gel, which reduces the size of the concrete's internal voids and greatly increases the watertightness of the concrete. For this reason, prolonged hydration through curing is a significant factor in attaining impermeable, watertight concrete. Keeping steel forms engaged for as long as possible

Curing enclosures used to maintain temperature and moisture.

can be an excellent means of protecting against loss of moisture.

Conventional curing and low-pressure steam curing are two of the more common methods of curing precast concrete products.

Conventional Curing

Conventional curing involves the continuous saturation of the concrete surface with water for a specified length of time, starting as soon as the concrete is no longer susceptible to damage at ambient temperatures. These conditions can be achieved by draping wet burlap or cotton mats, spraying, fogging or membrane curing.

If spraying or fogging is done at intervals, the concrete must be prevented from drying between applications. When burlap or cotton mats are used, they should be kept moist. Alternate cycles of wetting and drying can cause surface crazing or cracking. For low water-cement ratios wet curing is highly desirable.

Membrane curing is another method of conventional curing using polyethylene sheeting, curing compounds or similar material. With membrane curing, external water is not used in the curing process. This method should be used with caution for products with water-cement ratios less than 0.5, however, due to the potential for self desiccation. This method is also not recommended for concretes containing pozzolans.

Polyethylene sheeting should be at least 4 milliliters thick and should be applied to the concrete as soon as the concrete has hardened sufficiently. Sheets should be lapped (about 18 inches) and weighted, as needed. All exposed surfaces, including exposed edges and joints, must be protected against moisture evaporation.

Curing compounds should be sprayed uniformly on surfaces as soon as the water shine disappears but when the surface is still moist enough to ensure adequate performance (1-3 hours after concrete placement). Curing compounds should be stirred or agitated as needed before spraying. Curing compounds should be applied in two directions (vertically and horizontally) to ensure full coverage and should not be thinned or otherwise modified. Curing compounds are available in clear and colored (white) formulations. Colored formulations are easier for verifying full coverage.

Low-Pressure Steam Curing

Low-pressure steam curing adds moisture and increases the temperature, which are important factors that accelerating the curing process. Both result in an increased rate of hydration.

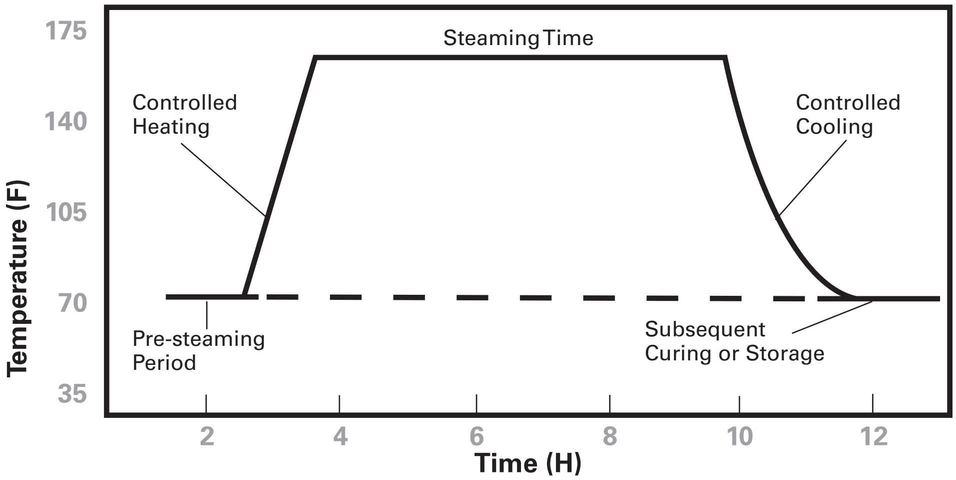


Figure 2: The wet-cast curing cycle.

Low-pressure steam curing can be performed in an enclosed permanent structure or in a temporary enclosure formed by a heavy tarp.

To achieve the best results when steam curing:

1. Apply elevated temperatures after the initial set of the fresh concrete. This is usually a period of 2 to 4 hours.
2. Apply a gradual temperature rise of not more than 40 F/hr, up to a maximum temperature between 120 F and 140 F.
3. Maintain a relative humidity between 75-90%
4. Gradually lower the temperature at a rate not to exceed 20 F per hour to avoid any thermal shock. Moisture evaporates very quickly from a hot surface and the durability to weathering and atmosphere will be detrimentally affected. Too rapid an evaporation rate at low humidity will cause the surface to dry out and produce a concrete structure that has a permeable, poorly cured surface with relatively poor durability.
5. Continue moist curing after steaming, as needed.

Other methods or techniques for accelerated curing:

1. Molds and form work should be left on as long as possible. When stripped, the concrete should be covered, preferably with wet burlap. The prime goal is to decrease the temperature of the concrete to the ambient temperature without causing distress.
2. Start with concrete that is as warm as possible and ensure that all plant equipment is warm at the start of concreting. Where hot water is used, it should be added and mixed into the aggregates. Cement should be added as the final ingredient.
3. When the concrete product has thin sections with openings, maximum temperatures may need to be decreased. Excessive temperature can result in excess loss of water.
4. Assess the applicability and performance of admixtures under accelerated curing conditions. Practices recommended under normal temperature curing may not be applicable.

Details on other accelerated curing methods can be found in ACI 517.2R, Accelerated Curing of Concrete at Atmospheric Pressure.

Special Conditions

Special precautions are needed when the temperature is either below 50 F or above 90 F. Hydration proceeds at a much slower rate when the concrete temperature is low. Temperatures below 50 F are considered unfavorable. Ideally, precast concrete operations should be performed in heated enclosures that will provide uniform heat to the products. In these cases, it is common practice to heat the mixing water and even the aggregate if necessary. Water should not be heated above 140 F. Further recommendations on cold weather concreting are included in ACI 306, Cold Weather Concreting.

Hydration rates are accelerated when the temperature is higher. When the ambient temperature is above 90 F, the temperature of the concrete as mixed should be kept as low as possible by shading the aggregate piles. Sprinkling aggregates with water will cool them by evaporation. In extreme cases, ice may be used in the mix water. In all cases, freshly cast products should be protected from the direct sunlight. Further recommendations on hot weather concreting are included in ACI 305, Hot Weather Concreting.

Conclusion

Curing, particularly within the first few hours after concrete placement, is one of the most important factors in manufacturing top quality precast concrete products. Properly cured precast concrete will achieve both superior early strength and long-term strength. Properly cured precast concrete products are also less permeable, more durable and display greater surface hardness.

References

ACI 305R-10, Hot Weather Concreting

ACI 306R-10, Cold Weather Concreting

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