MASTER® BUILDERS SOLUTIONS

Technical Bulletin

Curing Concrete

Introduction

Suggested procedures prepared by the Admixture Systems business of Master Builders Solutions in the interest of better concreting practices.

Note: The discussion pertains only to the curing of non-colored concrete for normal applications. Special curing procedures are required for colored, architectural or any exceptional types of concrete. It is advisable to contact the material manufacturer in such cases. For detailed information on recommended practices for curing concrete, refer to ACI 308R, *Guide to Curing Concrete*.

What is Curing

Curing is the process by which concrete matures and develops hardened properties over time as a result of continued hydration of the cementitious materials in the presence of sufficient water and heat. The objectives of curing are to prevent the loss of moisture from concrete and, when needed, supply additional moisture and maintain a favorable concrete temperature for a sufficient period of time.

Why Concrete Has to Be Cured

Curing has a significant influence on the properties of hardened concrete. All the properties of hardened concrete are affected by curing. Proper curing results in a concrete that has the right strength, low permeability, high abrasion resistance, reduced shrinkage, and high resistance to freezing and thawing. Insufficient and/or intermittent curing will affect all these properties.

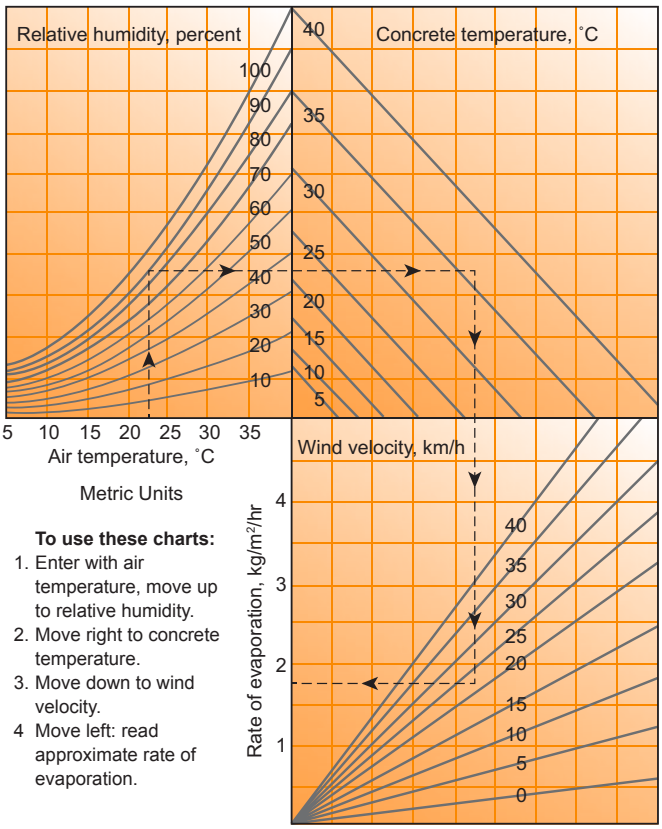
When to Start Curing

Curing should start when the concrete surface begins to dry, which starts as soon as the bleed water starts to evaporate faster than it can rise to the concrete surface. The time at which drying and the need for curing begins depends on the environment (temperature, humidity and wind speed) and also the characteristics of the concrete. Figure 1 shows the effect of concrete and air temperatures, relative humidity, and wind velocity on rate of evaporation of surface moisture from concrete. This figure can also be used to estimate the rate of evaporation of moisture from the surface of concrete. When the rate of evaporation exceeds the critical evaporation rate for the concrete that has been placed, typically about 0.2 lb/ft^2 (1 kg/m^2) per hour, precautionary measures are necessary and initial curing needs to be started to prevent or minimize plastic shrinkage cracking. For example, a cool, humid and windy day may have more evaporation than a hot, dry day with no wind. Furthermore, the critical evaporation rate is dependent on the concrete mixture and is influenced by factors that include the type and amount of supplementary cementitious materials, and the water-cementitious materials ratio (w/cm); a silica fume concrete will bleed less than a normal concrete and needs curing earlier than normal concrete. Using synthetic microfibers, such as the "MasterFiber® M or F" series of fibers from Master Builders Solutions in concrete helps in reducing plastic shrinkage cracking in freshly-placed concrete.

Additional measures should be taken in hot and cold weather conditions. ACI Committee reports 305R, *Guide to Hot Weather Concreting* and 306R, *Guide to Cold Weather Concreting* give the details of the measures to be taken during those extreme weather conditions.

Duration of Curing

The duration of curing depends on a number of factors, such as, the type of cementitious materials used, mixture proportions, strength required, size and shape of the member, ambient weather and future exposure conditions. A minimum of 7 days of curing is recommended. It is also not uncommon to terminate curing when the concrete has reached a minimum of 70% of the specified strength based on the test results of field-cured samples as per ACI 301 (ACI 301M), *Specifications for Structural Concrete*.



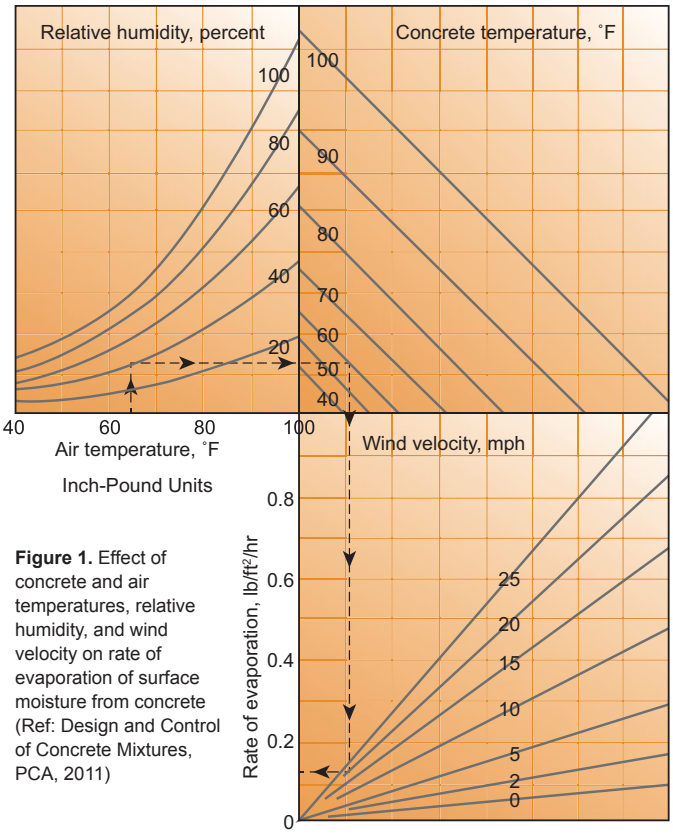


Figure 1. Effect of concrete and air temperatures, relative humidity, and wind velocity on rate of evaporation of surface moisture from concrete (Ref: Design and Control of Concrete Mixtures, PCA, 2011)

Figure 2 below shows the efffect of curing on the compressive strength of concrete. As can be seen from Figure 2, strength gain of concrete slows down when curing stops.

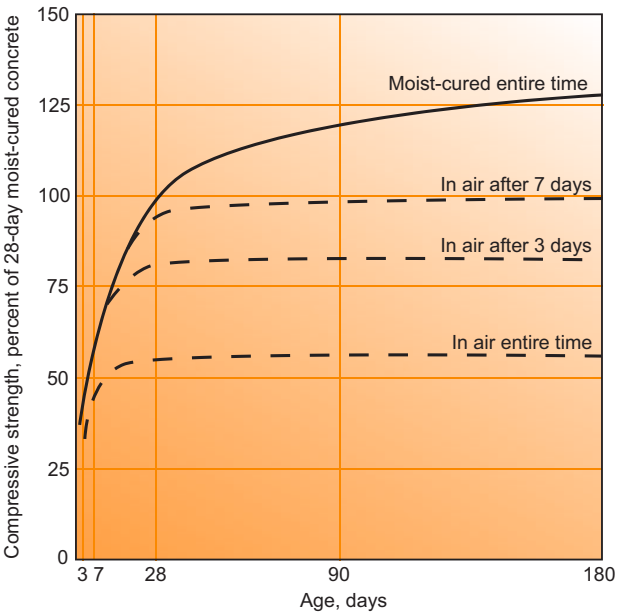


Figure 2. Effect of Curing on Compressive Strength of Concrete (Ref: ACI 308R, Guide to Curing Concrete)

Curing Methods

There are two general systems of curing:

1. Continuous or frequent application of water through ponding, fogging, steam or saturated cover such as burlap or cotton mats, rugs, sand, and straw or hay, and
2. Minimization of water loss from concrete by covering it with plastic sheets, blankets or other moisture-retaining materials or by the application of a membrane-forming curing compound.

Curing measures are required as soon as the concrete is at the risk of drying and its damaging effects. Curing should be started early when the rate of evaporation of water from the freshly-placed concrete is high and there is a tendency for concrete to dry faster. Different methods are suggested in ACI 308R for the initial and final curing of concrete.

1. **Initial Curing:** Two methods suggested for initial curing are fogging and the application of evaporation reducers.

   Fogging: Fogging is the application of water in the form of fog-like mist above the concrete surface, using a specially designed nozzle.

   Evaporation reducers: Evaporation reducers, such as MasterKure® ER 50 from Master Builders Solutions, are solutions of organic chemicals. These produce a monomolecular film over the bleed water layer on the concrete surface. This film reduces the evaporation of water from the surface of concrete. Care shall be taken not to use evaporation reducers as finishing aids.

2. **Final curing:** Final curing can be done either by use of water or by moisture retention.

   Curing methods based on application of water: Water could be sprinkled or ponded on the surface of concrete. Alternatively, wet burlap, cotton mats or other absorbent materials, wet sand, wet straw or hay could be used for curing concrete. It is very essential that all these materials are kept continuously wet for the duration of curing.

   Curing methods based on moisture retention: Curing materials used in this method are sheets or liquid membrane-forming compounds. Plastic film, reinforced paper and thermal blankets are the sheet-type curing materials commonly used. Membrane-forming compounds, commonly known as curing compounds, such as “MasterKure” series of products from Master Builders Solutions, conforming to ASTM C 309 or C 1315 are used as curing aids. These shall be spray-applied on the concrete surface. ACI 308R has the details of linseed oil-based curing compounds that are specified by some highway agencies.

Curing in Cold Weather

Water curing is not allowed during sub-freezing temperatures. A moisture retention method such as membrane-forming curing compound shall be employed instead. Additionally, the adjacent concrete environment could be heated to a temperature above freezing.

Heaters, if used, shall be vented so that the combustion gases are exhausted outside the enclosure in order to avoid carbonation of the fresh concrete.

Curing in Hot Weather

During the initial curing period, use evaporation reducers, fogging or shade to control the rate of bleed water evaporation and subsequent drying of the concrete. The temperature of curing water shall not be more than 20 ºF (10 ºC) cooler than the surface temperature of concrete at the time the water and concrete come in contact.

Perform final curing methods immediately upon completion of the final finishing operation.

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