Lesson 6: Curing Concrete

Once concrete has been poured, the curing process begins to take place. While it may seem that the concrete is merely drying, a chemical process called hydration is in action. Curing is necessary because this chemical process gives concrete its strength. If it does not cure properly, the result is substandard concrete.

The Process of Concrete Curing

After concrete has been poured into forms and exposed to the air, it begins to harden in a process called curing. Most people think that concrete hardens because of evaporation or drying, but they are not correct. If concrete were to simply dry out, nothing would hold it together, and the materials would separate out. The curing of the concrete is the result of hydration, which is the mixing of a compound with water.

The curing process involves a chemical reaction between water and the elements in Portland cement. As the cement starts to react with the water, a substance called a gel is formed from the chemicals in the cement and water. The gel has a consistency similar to gelatin. Eventually the gel becomes a solid mass, thickening and hardening the concrete.

The rate of curing for pure concrete without additives is affected by temperature. The ideal temperatures for curing are between 65 and 75 degrees Fahrenheit. Temperatures higher than 75 degrees will cause the concrete to cure too quickly by creating excess evaporation; the concrete will then lose strength. In temperatures between 32 and 65 degrees Fahrenheit, concrete will cure, but the process will be slower. At temperatures below 32 degrees, the concrete will not cure. If concrete freezes during curing, permanent damage will occur.

The length of time that pure concrete is allowed to cure depends on the outside temperature. Generally, if air and soil temperatures are above 70 degrees Fahrenheit, the concrete should be allowed to cure for at least five days. If temperatures are 50 to 70 degrees Fahrenheit, the concrete should be allowed to cure for at least seven days. If the temperature is less than 50 degrees Fahrenheit, the concrete should cure for at least seven to ten days, and preferably longer. In all cases, the ideal curing time is 28 days, because the process continues until about that time.

No extra weight should be placed on the concrete during curing because it will stop the curing process. Keeping weight off the concrete will also increase its final strength. Construction of the structure should wait until the concrete has completely cured.

Determining if the concrete has cured completely is difficult. The outside layer or shell of the concrete will cure first, with the inside curing last. No direct method exists for determining if the concrete on the inside has cured. The outside is cured when the concrete becomes light gray in color.

The Importance of Curing

Curing is important because it causes the concrete to harden and determines its strength. To a point, the more water the concrete can retain, the greater its strength will be. For maximum strength, the concrete must have adequate water to continue the chemical reaction until it has completely hardened. Only about half of the water in concrete is needed for hydration. The rest is needed to make the concrete flow and be workable. Too much water will cause incomplete curing because the gel particles cannot join together to harden and set.

Curing also gives concrete the ability to hold water in or out. Because so many concrete applications call for the ability to contain water or keep it out, curing is very important. For example, if the walls in the basement of a house do not completely cure, water will seep in from the soil, and moisture will always be present in the house. Concrete cured for only one day would not be waterproof, while concrete cured for three days would be somewhat but not completely watertight. Concrete cured for seven days is completely watertight.

Curing Concrete

One of the most important factors affecting curing is the temperature. Different approaches are necessary when curing concrete in temperatures below 50 degrees Fahrenheit or

Cold Weather Curing

Concrete should never be poured onto frozen soil because the ground will cause the water in the concrete to freeze, halting the curing process completely. The ground should be heated using propane torches.

When pouring concrete in temperatures below 50 degrees Fahrenheit, the concrete should be heated so that it is between 60 and 80 degrees Fahrenheit as it hits the forms. The concrete can be heated by heating the water added to the mixture.

After pouring, protection should be provided for the forms in order to retain the heat in the concrete. This protection can be in the form of straw, plastic, or paper spread directly on the surface of the concrete, sealing the heat and moisture in. The cover should remain over the concrete for at least 48 hours and preferably for four to five days.

Another option for heating the concrete is to build an enclosure around the forms and heat the entire area with fuel-burning heaters. Heaters should be used with caution, because the carbon dioxide they give off will sometimes react with the concrete to form a thin layer of calcium carbonate over its surface, which will be weak and chip off. To avoid this problem, adequate ventilation for the exhaust fumes from the heater is necessary.

The forms should be left around the concrete for as long as possible. They will act as insulation, retaining the heat in the concrete.

One way to test whether the concrete froze during curing is to pour hot water on it. If the concrete has cured properly, nothing will happen. If the concrete did freeze, however, its surface will become soft and mushy. The concrete will need to be chipped or broken out and poured again.

Hot Weather Curing

In hot weather, some important factors need to be considered to allow maximum curing. If outside temperatures are above 80 degrees Fahrenheit, more water will be needed in the

above 80 degrees Fahrenheit.

concrete mixture to maintain the optimal slump of 1 to 3 inches because some of the water evaporates due to the heat and mixing. High temperatures will also shorten the time that the concrete can be worked or finished because of the more rapid evaporation of the surface water. Reducing the time needed for pouring by having plenty of labor available is important in warm temperatures. The more time it takes to place the concrete, the more water will evaporate, affecting curing.

Hot weather can cause incomplete curing due to the rapid curing of the outside layer of the concrete. Although the outside is cured, the inside may not be. This condition is difficult to detect and may not be noticed until later, when the concrete does not have sufficient strength for a given situation.

Several methods can be used to keep the concrete cool. The easiest method of maintaining the optimal temperature is to cool the ingredients of the concrete as they are mixed. The temperature of the mix can be reduced by adding cold water. Dampening the subgrade will reduce the heating of the concrete as it is poured into the forms. Wet burlap can be placed over the concrete to help cool the surface. Lightly spraying cold water on the concrete will also cool it. However, the concrete should only be sprayed once the surface has been finished and has hardened, so it does not show indentations from the water droplets.

Moist Curing

Another factor that affects curing is moisture. Ideally, concrete should be cured with as little moisture evaporating from the surface as possible. Retaining the moisture on the surface of the concrete is called moist curing. Moist curing can be accomplished using a variety of methods. Some of these methods include placing moist burlap sacks over the surface of the concrete, spraying the surface with water, covering it with waterproof paper, covering the surface with plastic sheets, or spraying the concrete with a curing compound, which places a chemical membrane over the concrete to seal in the moisture. Four main types of curing compound are used: clear or transparent, black, white, and light gray. These curing compounds may cause a permanent change in the color of the surface of the concrete.

Concrete Defects

Concrete defects are faults in the surface of the concrete. They are usually only apparent after curing. These defects have many different causes, including poor materials, improper mix design, improper pouring and curing, or poor workmanship. The faults are difficult, if not impossible, to repair without tearing out the faulty concrete and replacing it.

Honeycomb surfaces result from the use of a concrete mixture that was too dry and needed more water to mix completely. The lack of water causes air pockets around the unmixed dry materials, resulting in a honeycomb structure. To prevent honeycomb faults, the mix must be moist enough. The edges of the forms should also be spaded to avoid dry spots.

Air pockets are holes left in the concrete after curing due to the presence of a confined body of air. They can generally be prevented by spading the edge of the forms. Wiping oil on the surface of the forms will decrease the frequency of air pockets because the oil allows the air to escape more readily.

Rock pockets or gravel streaks are related defects caused by cracks or knotholes in the forms that allow the mortar, which is the cement and water paste, to flow out, leaving pockets and veins of coarse aggregate. While these faults can easily be prevented, they are generally difficult to repair.

Sand streaking involves small ribbons of sand running across the surface of the concrete. This defect is usually caused by a mixture that was too wet. As a result, the coarse aggregates sink and separate out from the rest of the mixture, leaving the fine aggregate to work to the top. This fault is difficult to repair.

If the surface of the concrete is stained red to pink in color, the coloring is the result of the resin in the plywood forms reacting with the concrete. The discoloration will generally happen with forms used for the first time and will diminish with continued use. Using older forms will greatly reduce this problem. The color is difficult to remove from concrete but will fade and disappear in time. Since it is not permanent, this defect does not greatly affect the quality of the concrete.

Rust stains are caused by steel reinforcement that has worked to the edge or surface of the concrete. If the reinforcement is fully covered by concrete, these stains will not occur. The stains can be cleaned from the concrete using a chemical solution of diluted oxalic acid but will reappear as long as the exposed metal is present.

Dusting is the appearance of a powdery material on the surface of newly hardened concrete. Dusting has several different causes, including excess clay or silt in the concrete, premature floating and troweling, the addition of carbon dioxide from heating systems, the condensation of water on the surface before floating and troweling have been completed, dry-heat heaters that lower the humidity too quickly and cause incomplete curing, or inadequate or no curing due to insufficient water in the mixture. Dusting cannot be fixed, only prevented. If the concrete has dusted, it will have reduced strength. The concrete may need to be chipped or broken out and poured again if it is not strong enough.

Scaling occurs when the surface of hardened concrete slabs breaks away to a depth of 1/16 to 3/16 of an inch. This defect may be caused by the freezing and thawing of newly placed concrete, the freezing and thawing of concrete that is not air-entrained, the application of deicing salts on concrete that is not air-entrained, and faulty workmanship caused by finishing the concrete while it was still "bleeding" or giving off water. Scaling cannot be repaired.

Crazing is the presence of numerous fine hairline cracks in the surface of a newly hardened slab due to shrinkage. Crazing can be caused by rapid surface drying by the sun or wind, premature floating and troweling on a moist surface along with the rapid loss of moisture, or the overuse of tools such as a power screed or bull float, which works too much mortar to the surface of the concrete. Crazing cannot be corrected.

Removal of Forms

Forms can be removed when the concrete has cured sufficiently to support its own weight. The amount of time will vary according to the weather. In summer or warm weather conditions, the forms can be removed two days after pouring. In winter or cold weather conditions, the forms should not be removed for at least four to seven days. Forms can be removed in less time if accelerating additives are used; they can cut the curing time in half. Any reinforcement around the forms should be loosened prior to their removal, including all the duplex nails holding the forms together. If the forms were properly coated with oil, they should come away easily, without the use of force. The forms should then be cleaned to remove any concrete residue before storing them away for future use. The slab can be cleaned with water once the forms have been removed.

Summary

Curing is the hardening of concrete, which gives it strength and allows it to resist water. Curing requires temperatures of 65 to 75 degrees Fahrenheit for optimal curing, although curing concrete in hotter and colder temperatures is possible using the proper additives and procedures. Many defects may occur if the concrete is mixed, poured, worked, or cured improperly, resulting in concrete that is weak or has a poor appearance.

Credits

Ahrens, Donald L. *Concrete and Concrete Masonry*. St. Paul, Minn.: Hobar Publications, 1976.

Boyd, James S., and Carl L. Reynolds. *Practical Farm Buildings*. 3rd. ed. Danville, Ill: Interstate Publishers, 1993.

Cooper, Elmer L. *Agricultural Mechanics: Fundamentals and Applications*. Albany, N.Y.: Delmar Publishers, 1997.

Granite Rock Company. "Concrete Surface Defects - Causes, Prevention and Repair." http://www.graniterock.com/tn.htm (12 Dec. 1998).

Lindley, James A., and James H. Whitaker. *Agricultural Buildings and Structures.* Rev. ed. St. Joseph, Mich.: American Society of Agricultural Engineers, 1996.

Materials Science and Technology (MAST) Teacher's Workshop. "Concrete." Produced by the Department of Materials Science and Engineering at the University of Illinois, Urbana/Champaign. http://mach-pc66.mse.uiuc.edu/~tw/concrete/concrete.html (29 Aug. 1998).