Placement of Concrete in Hot Weather

An Online Continuing Education Course for Engineers

Course Number: C-1010

Credit: 1 Hour / 1 PDH / 1 CPD

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Introduction

In addition to quality control procedures that are routinely necessary to achieve quality concrete, there are additional requirements imposed by hot weather. Hot ambient temperatures increase the rate of setting and also increase the likelihood of shrinkage cracking. The rate of setting refers to how quickly the new concrete changes from a fluid to a hard mass. An increased rate of setting results in decreased time available for workers to place and properly consolidate concrete and a higher risk of cold joints. Because hot weather accelerates the setting process, concrete must be placed in a timely manner to avoid the formation of layers of concrete. These layers will result in planes of weakness. Shrinkage cracking increases because of a higher rate of surface water evaporation as compared to concrete placed at moderate temperatures.

Hot weather also has an impact on slump. Higher temperatures will necessitate higher water content in the mix design to maintain the same slump used at lower temperatures. This increased water content will result in decreased strength. For example, if the intent is to place concrete with a 3 inch slump, concrete placed in July will require more water than concrete placed in November. Adjustments have to be made to the water cement ratio in the mix design to properly account for the difference in the ambient temperature at different times of the year.

In addition to high ambient temperature there are other factors that impact the quality of concrete in hot weather. Relative humidity and wind velocity also affect the quality of concrete. High relative humidity is an aid to the proper curing of fresh concrete. However, high ambient temperatures are frequently accompanied by low relative humidity in arid environments. Hot and dry ambient air will result in the rapid evaporation of surface water in fresh concrete and in an increased risk of shrinkage cracking. To make matters worse, high ambient temperatures and low humidity can also combine with windy conditions to make the successful placement of concrete a risky endeavor. The potential for shrinkage cracking can be evaluated by studying the attached chart (Figure 13-8) published by the Portland Cement Association (click the link on the course summary page to access the chart). Notice that the potential for shrinkage cracking is high once the velocity of the wind is more than a slight breeze.

Once shrinkage cracks start to appear because of the preceding conditions the natural inclination is to add more water and rework the surface. The addition of water should not be permitted. Excess water will result in a weak layer of paste at the surface. The problem may not be immediately evident, but will eventually manifest itself in the form of spalling and flaking of the surface. The best way to avoid a problem with shrinkage cracks is to be aware of the risk and to start curing promptly before the problem arises.

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Preparation for placement

The placement of concrete should be planned and discussed prior to commencement of work. Typically, the representative of the owner, the Quality Control Manager, a technical representative of the concrete supplier, and the foreman of the concrete crew will meet to discuss placement procedures. The size of the placement, the expected weather conditions, the equipment and materials needed, and the timing of the ready mix trucks should all be discussed and a plan of action adopted. The placement plan should identify what work is going to be done, who is going to do it, and when the placement is going to be done to avoid errors due to a lack of communication.

Planning should also include a plan of action for emergencies and problems that may arise during placement. For example, extra vibrators need to be available in the event that the vibrators being used to consolidate the concrete should fail or malfunction. The technical representative of the concrete supplier should be consulted regarding the selection of a suitable mix design, anticipated travel time, haul routes and distances, and recommendations regarding the cooling of aggregates and water. The cooling of water with ice is an effective and simple method of lowering concrete temperature. The cooling of aggregates should also be considered. A concrete temperature of 60 degrees Fahrenheit is generally considered desirable. A maximum of 85 or 90 degrees is generally specified. The specifications may stipulate a maximum allowable concrete temperature based on the relative humidity at the time of the placement.

Because setting time is accelerated by hot weather, the use of a retarder may be considered. A retarder is an admixture that increases the setting time of the concrete. An increased setting time gives the concrete crew more time to properly place and consolidate the concrete placement. Admixtures, such as retarders, are used to modify the characteristics of concrete in response to environmental circumstances at the time of the placement or other considerations. Consideration should be given to placing concrete early in the morning to avoid the high ambient temperature during the afternoon. Once all of the preceding factors have been considered and discussed, a mix design and a placement plan can be selected.

Inspection of forms, subgrade, underground plumbing, and reinforcing steel for compliance with specifications should be done at least a day before concrete is ordered. Forms should be checked for correct elevations. Floor slabs and footings should be checked to ensure correct location and dimensions. Equipment to be used during the placement should be checked for proper operation and for adequate amount to handle the placement. Vibrators should be checked for amplitude and frequency. Portable generators should be checked for operation and for fuel. Items that are to be embedded in the concrete, such as anchor bolts, should be checked for correct location, quantity, and elevation.

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In hot weather, forms and reinforcing should be sprayed with water to prevent wood forms from absorbing moisture from the concrete and to keep steel reinforcing from becoming hot. The bottom of trenches where concrete footings are to be placed should be kept moist, clean, and free of debris. However, puddles of water are not acceptable. The intent is to prevent dry soil from absorbing water from the fresh concrete. Reinforcing steel should be clean and free of rust. Forms and steel can also be covered to minimize the temperature gain caused by direct sunlight on steel reinforcing. The tying of reinforcing steel and other last minute adjustments while the ready mix truck is waiting is a practice that may lead to mistakes and should be avoided.

Placement

The delivery of concrete should be monitored for compliance with ASTM C 94. C94 requires that the total time from water being added to the cement and aggregates to concrete being inside the forms be less than 1.5 hours or before 300 revolutions of the ready mix truck drum. The preceding standard is for normal situations and conditions. In hot weather the 1.5 hour time limit may have to be reduced because of the faster setting time for concrete under hot conditions. If the temperature of the concrete exceeds 85 degrees, then the preceding time limit should be reduced to 60 minutes or 45 minutes.

Concrete temperatures should be checked and recorded for documentation and control purposes. A simple pocket thermometer is handy. The recording of concrete temperatures, ambient temperature, and other weather conditions at the time of placement should be done by the contractor. These duties can become very important in the event that the concrete has to be removed due to unacceptable cracking, cold joints, segregation of aggregate, or failed compressive strength tests. Good documentation helps to pin point the source of the problem and identify the liable party. Thorough documentation is an aid to determining if the problem was caused by poor workmanship, poor or improper curing, defective curing compound, or faulty concrete because of mixing or batching problems.

Samples of concrete should be taken per the frequency stipulated by contract to verify compliance with the slump and air requirements. The preparation and care of concrete cylinders has to be monitored for proper handling procedures. The concrete has to be deposited as closely as possible to the final location. Concrete for slabs on grade should be placed against the forms at one end of the slab with new deliveries placed against the previous batch. Concrete should not be dropped more than 5 feet. Concrete that is dropped from heights greater than 5 feet will segregate. An effective method of placing concrete in hot weather is to pump the concrete into the forms. Pumping is effective because it places the concrete exactly where it is needed in a minimum amount of time.

Concrete should not be dumped in separate piles and then moved to the final location by use of vibrators. This practice tends to cause segregation of the concrete. During the placement of concrete into tall slender forms such as columns, care must be taken to prevent segregation of particles caused by the dumping of the concrete into the form. The use of a tremie or chute may be required or advisable.

After concrete has been placed into the forms, concrete slabs on grade and concrete paving require additional work before curing. Large unformed concrete surfaces will require finishing of the surface. The concrete surface needs to be screeded to give a level surface at the correct elevation. Screeding is simply the striking off of excess concrete with a straightedge. A 2x4 wood stud is usually moved in a back and forth motion through the fresh concrete to remove humps.

After screeding, the concrete surface is finished with a bullfloat. A bullfloat has a flat blade with a long handle and is usually made of aluminum. The long handle allows the worker to reach areas in the middle of the slab. Bullfloating will give a flat even surface. In situations where a hard surface is desired, the floating of the surface is followed by steel troweling. Steel troweling will produce a smooth hard surface. When finishing of the concrete is completed, the next step is curing.

Curing

Once the concrete has been delivered, placed, and finished the next operation left to accomplish is curing. Curing is defined as the process of retaining the moisture in the concrete to allow for the proper hydration of cement and the corresponding increase in compressive strength. The degree to which this chemical reaction is completed determines the quality of the new concrete.

Specifications will generally require that new concrete be cured by an approved method for at least 3 to 7 days. The compressive strength of the new concrete will increase rapidly in the first 7 days and at a slower rate thereafter. The specifications will require that the concrete cylinders taken at the time the concrete was placed be tested for compressive strength at 7 and 28 days. The tests done at 7 days will give a good indication of whether the concrete will meet the 28 day compressive requirements in the contract. The tests done at 28 days after the placement must meet the compressive strength specified in the contract. For example, the specifications might require that the cylinders tested at 28 days break at 3,500 psi.

Regardless of the curing method, the uncontrolled loss of surface water in fresh concrete will result in shrinkage cracks at the surface of the new placement. All of the time and effort involved in planning, placing, and finishing the concrete can be negated by improper curing. During the curing period, concrete also needs to be protected from extreme changes in temperature and from damage caused by foot or vehicular traffic or rainfall. Additionally, no sources of heat, such as torches, should be allowed near new concrete because of the rapid drying effect on the concrete surface of these devices. A moderate ambient temperature and medium or high humidity are ideal conditions for the placement and curing of concrete. In practice, concrete is seldom placed and cured under ideal conditions.

Moist Curing

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The most common method of curing concrete is by moist curing. The surface is kept moist by a continuous fog of moist air or by burlap that has bee ... water. A fog of moist air is an effective method of curin ... be taken during windy conditions ... ture intended for the co ... on the ... eriods of ... acks.

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Curing C...

Another and less complicated method of curing concrete is by the use of curing compound. This method involves the use of a pigmented curing compound or a clear compound with a dye. The dye is used as a visual aid so that proper application of the compound is assured.