Concrete in Practice

What, why & how?

NRMCA®

CIP 5 - Plastic Shrinkage Cracking

WHAT is Plastic Shrinkage Cracking?

Plastic shrinkage cracks appear in the surface of fresh concrete soon after it is placed and while it is still plastic. These cracks appear mostly on horizontal surfaces. They are usually parallel to each other on the order of 1 to 3 feet apart, relatively shallow, and generally do not intersect the perimeter of the slab. Plastic shrinkage cracking is highly likely to occur when high evaporation rates cause the concrete surface to dry out before it has set.

Plastic shrinkage cracks are unsightly but rarely impair the strength or durability of concrete floors and pavements. The development of these cracks can be minimized if appropriate measures are taken prior to and during placing and finishing concrete.

(Note: Plastic shrinkage cracks should be distinguished from other early or prehardening cracks caused by settlement of the concrete around reinforcing bars, formwork movement, early age thermal cracking, or differential settlement at a change from a thin to a deep section of concrete.)

WHY Do Plastic Shrinkage Cracks Occur?

Plastic shrinkage cracks are caused by a rapid loss of water from the surface of concrete before it has set. The critical condition exists when the rate of evaporation of surface moisture exceeds the rate at which rising bleed water can replace it. Water receding below the concrete surface forms menisci between the fine particles of cement and aggregate causing a tensile force to develop in the surface layers. If the concrete surface has started to set and has developed sufficient tensile strength to resist the tensile forces, cracks do not form. If the surface dries very rapidly, the concrete may still be plastic, and cracks do not develop at that time; but plastic cracks will surely form as soon as the concrete stiffens a little more. Synthetic fiber reinforcement incorporated in the concrete mixture can help resist the tension when concrete is very weak.

Plastic Shrinkage Cracks

Conditions that cause high evaporation rates from the concrete surface, and thereby increase the possibility of plastic shrinkage cracking, include:

- Wind velocity in excess of 5 mph
- Low relative humidity
- High ambient and/or concrete temperatures

Small changes in any one of these factors can significantly change the rate of evaporation. ACI 305 provides a chart to estimate the rate of evaporation and indicates when special precautions might be required. However, the chart isn't infallible because many factors other than rate of evaporation are involved.

Concrete mixtures with an inherent reduced rate of bleeding or quantity of bleed water are susceptible to plastic shrinkage cracking even when evaporation rates are low. Factors that reduce the rate or quantity of bleeding include high cementitious materials content, high fines content, reduced water content, entrained air, high concrete temperature, and thinner sections. Concrete containing silica fume requires particular attention to avoid surface drying during placement.

Any factor that delays setting increases the possibility of plastic shrinkage cracking. Delayed setting can result from a combination of one or more of the following: cool weather, cool subgrades, high water contents, lower cement contents, retarders, some water reducers, and supplementary cementing materials.

HOW to Minimize Plastic Shrinkage Cracking?

Attempts to eliminate plastic shrinkage cracking by modifying the composition to affect bleeding characteristics of a concrete mixture have not been found to be consistently effective. To reduce the potential for plastic shrinkage cracking, it is important to recognize ahead of time, before placement, when weather conditions conducive to plastic shrinkage cracking will exist. Precautions can then be taken to minimize its occurrence.

a. When adverse conditions exist, erect temporary windbreaks to reduce the wind velocity over the surface of the concrete and, if possible, provide sunshades to control the surface temperature of the slab. If conditions are critical, schedule placement to begin in the later afternoon or early evening. However, in very hot conditions, early morning placement can afford better control on concrete temperatures.

b. In the very hot and dry periods, use fog sprays to discharge a fine mist upwind and into the air above the concrete. Fog sprays reduce the rate of evaporation from the concrete surface and should be continued until suitable curing materials can be applied.

c. If concrete is to be placed on a dry absorptive subgrade in hot and dry weather, dampen the subgrade but not to a point that there is freestanding water prior to placement. The formwork and reinforcement should also be dampened.

d. The use of vapor retarders under a slab on grade greatly increases the risk of plastic shrinkage cracking. If a vapor retarder is required, cover it with a 3 to 4 inch lightly dampened layer of a trimable, compactible granular fill, such as a crusher-run material.

e. Have proper manpower, equipment, and supplies on hand so that the concrete can be placed and finished promptly. If delays occur, cover the concrete with moisture-retaining coverings, such as wet burlap, polyethylene sheeting or building paper, between finishing operations. Some contractors find that plastic shrinkage cracks can be prevented in hot dry climates by spraying an evaporation retardant on the surface behind the screeding operation and following floating or troweling, as needed, until curing is started.

f. Start curing the concrete as soon as possible. Spray the surface with liquid membrane curing compound or cover the surface with wet burlap and keep it continuously moist for a minimum of 3 days.

g. Consider using synthetic fibers (ASTM C 1116) to resist plastic shrinkage cracking.

h. Accelerate the setting time of concrete and avoid large temperature differences between concrete and air temperatures.

If plastic shrinkage cracks should appear during final finishing, the finisher may be able to close them by refinishing. However, when this occurs precautions, as discussed above, should be taken to avoid further cracking.

References

1. *Hot Weather Concreting,* ACI 305R, American Concrete Institute, Farmington Hills, MI.
2. *Guide for Concrete Floor and Slab Construction,* ACI 302.1R, American Concrete Institute, Farmington Hills, MI.
3. *Standard Practice for Curing Concrete*, ACI 308, American Concrete Institute, Farmington Hills, MI.
4. *Concrete Slab Surface Defects: Causes, Prevention, Repair*, IS177, Portland Cement Association, Skokie, IL.
5. Bruce A. Suprenant, *Curing During the Pour*, Concrete Construction, June 1997.
6. Eugene Goeb, *Common Field Problems*, Concrete Construction, October 1985.

Follow These Rules to Minimize Plastic Shrinkage Cracking

1. Dampen the subgrade and forms when conditions for high evaporation rates exist.
2. Prevent excessive surface moisture evaporation by providing fog sprays and erecting windbreaks.
3. Cover concrete with wet burlap or polyethylene sheets between finishing operations.
4. Use cooler concrete in hot weather and avoid excessively high concrete temperatures in cold weather.
5. Cure properly as soon as finishing has been completed.

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