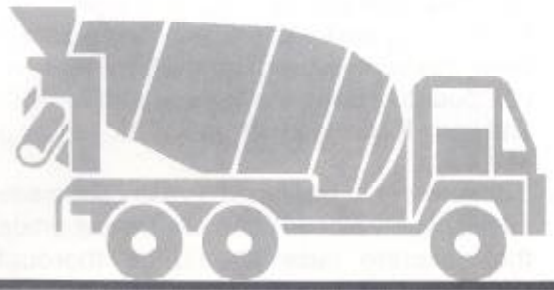

CONCRETE IN PRACTICE

CIP 5

What, Why & How? Plastic Shrinkage Cracking

WHAT Is Plastic Shrinkage Cracking?

Plastic shrinkage cracks are cracks that appear on the surface of a freshly placed concrete slab during finishing operation or soon after. These cracks are usually parallel to each other on the order of 1 to 3 feet apart, and 1 to 2 inches deep; and rarely do they intersect the perimeter of the slab.

Plastic shrinkage cracks rarely impair the strength of concrete floors and pavements; nevertheless, they are unsightly. The development of these cracks can be minimized if appropriate measures are taken prior to and during construction.

(Note: Plastic shrinkage cracks should be distinguished from other early or prehardening cracks caused by settlement of the concrete on either side of a reinforcing bar due to bleeding and resistance to settlement on either side of a top reinforcing bar, because of formwork movement, or differential settlement at a change from a thin to a deep section of concrete.)

WHY Do Plastic Shrinkage Cracks Occur?

Plastic shrinkage cracks occur when the rate of evaporation of surface moisture exceeds the rate at which rising bleed water can replace it and the surface dries. As the bleed water evaporates and recedes below the concrete surface, menisci develop 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, cracks do not form. However, if the surface dries before sufficient tensile strength develops, the tensile force in the surface layers will exceed the tensile strength and cracks will develop during the setting process. 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. Plastic fibers can help resist the tension when concrete is very weak.

Plastic Shrinkage Cracks

The rate of evaporation of water is higher when the relative humidity is low, the wind velocity is high, and when the concrete surface is warmer than the surrounding air. ACI 305 (1) provides a chart that can be used to estimate the rate of evaporation and to tell when special precautions need to be taken. However, the chart isn't infallible because many factors other than rate of evaporation are involved.

Increasing the cement content tends to increase plastic cracking. Two factors are involved: reduced bleeding, and the smaller menisci between the fine particles which produce higher tensile forces. Concrete containing silica fume requires very careful attention to rate of evaporation to avoid plastic shrinkage cracking. Increased slump tends to increase plastic cracking. Anything that delays setting tends to increase plastic cracking when the rate of evaporation is high. Examples include: cool weather, cool subgrades, lower cement content, retarders, and most water reducers.

HOW to Minimize Plastic Shrinkage Cracks?

Attempts to eliminate plastic shrinkage cracking by increasing the bleeding characteristics of the concrete either by increasing slump or by using different cement or aggregate or by addition of a retarder have not been found to be consistently effective. To reduce plastic shrinkage cracking, it is important to recognize ahead of time, before placement, when weather conditions may occur that are conducive to plastic shrinkage cracking. Precautions can then be taken to minimize its occurrence. They are:

a. 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 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 a chlorinated rubber curing compound, or monomolecular film, on the surface behind the screeding operation and before floating or troweling.
b. 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.
c. If concrete is to be placed on a dry subgrade or on previously placed concrete, the subgrade or the concrete base should be thoroughly dampened. The formwork and reinforcement should also be dampened.
d. The use of vapor barriers under a slab on grade greatly increases the risk of plastic shrinkage cracking. If a vapor barrier is required, cover it with a 2-inch layer of damp sand.
e. In the very hot and dry periods, use fog sprays. Erect temporary windbreaks to reduce the wind velocity over the surface of the concrete and, if possible, also provide sun shades to control the surface temperature of the slab. If conditions are critical, schedule placement to begin in the later afternoon or early evening.
f. Consider using synthetic fibers (ASTM C 1116) to resist plastic shrinkage cracking.
g. Make the concrete set faster.

References

1. ACI Standard Recommended Practice for Hot Weather Concreting (ACI 305R), *ACI Manual of Concrete Practices*, Part 2.
2. "Report on Behavior of Concrete in Hot Climate," by R. Shalon, *RILEM*. No. 62, March-April 1978.
3. "Plastic Shrinkage" by W. Lerch, *Journal of the American Concrete Institute*, Volume 28, No. 8, February 1957.
4. "Control of Rapid Drying of Fresh Concrete by Evaporation Control," by W. A. Cordon and J. D. Thorpe, *Journal of the American Concrete Institute*, Proceedings Volume 62, No. 8, August 1965.
5. "Cracking of Fresh Concrete as Related to Reinforcement," by P. D. Cady, et al, *Journal of the American Concrete Institute*, Proceedings Volume 72, No. 8, August 1975.

Follow These Rules to Minimize Plastic Shrinkage Cracking

1. Dampen the subgrade and forms.
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 overheating the concrete in cold weather.
5. Cure properly as soon as finishing has been completed.

NATIONAL READY MIXED CONCRETE ASSOCIATION

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