CONCRETE SASK

TECH TIP #5

www.concretesask.org

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 relatively short and usually parallel to each other on the order 0.3m to 0.9m (1' to 3') apart, and 10 to 50 mm deep. The cracks occur randomly and seldom intersect the perimeter of the slab. Plastic shrinkage cracking is more 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 of concrete floors and pavements. However, these cracks can permit the ingress of water and/or other aggressive chemicals that impact durability and as weak points for initiation of later age cracking due to other reasons. The development of these cracks can be minimized if appropriate measures are taken prior to and during placing and finishing operations.

WHY do plastic shrinkage cracks occur?

The most common explanation for the occurrence of plastic shrinkage cracking is that the rate of evaporation of surface moisture exceeds the rate at which it is being replaced by bleed water. This causes shrinkage of the surface while the underlying plastic concrete remains at the same volume. However, some field investigations have shown that the bleeding characteristics of concrete do not have a major influence on plastic shrinkage cracking. There is evidence that all cement paste shrinks during early hydration which produces very small micro cracks. When the rate of evaporation is high and the concrete has enough strength (or stiffness) to cause horizontal shrinkage, the normal micro cracking tendency is accentuated and noticeable plastic cracking may result.

The following are examples of weather conditions which increase the rate of evaporation and, therefore, the risk of plastic shrinkage cracking:

- Decrease in relative humidity: Changes in relative humidity have pronounced effects on the rate of evaporation. If the relative humidity changes from 90% to 50% the rate of evaporation is increased by 5 times.
- Increase in wind velocity: When wind blows across the surface of concrete during placement and finishing the evaporation of surface moisture will increase. For example, an increase in wind speed from 0 to 15 km/h will quadruple the rate of the evaporation.
- Temperature: If the temperature of both the concrete and the surrounding air rises, the rate of evaporation will increase. For instance, when the temperature of both concrete and air increases from 10 to 20 degrees C the rate of evaporation of water from the surface can double.
- Rapid evaporation and plastic cracking may also occur when the temperature of the concrete is significantly higher than the air temperature (and the "dew point" temperature). This can occur in cold weather with heated concrete even when the humidity is high and the concrete is placed indoors where the wind velocity is negligible.

Small changes in any of these factors can change the rate of evaporation of water from the concrete surface. CSA A23.1-24, Annex D, Figure D.1, provides a chart to estimate the rate of evaporation and indicates when special provisions may be required. This chart is not infallible, however, 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 affect the rate or quantity of bleeding include high cementitious materials content, high fines content, reduced water content, entrained air, high temperature and thinner sections. Concrete containing silica fume requires particular attention to avoid surface drying during placement due to its very low rate of bleeding.

Any factor which delays setting increases the possibility of plastic shrinkage cracking. Delayed setting can result from one or more of the following: cool weather, cool subgrades or surfaces, high water contents, lower cement contents, retarders, some water reducers and supplementary cementitious materials (SCMs).

HOW to minimize plastic shrinkage cracking?

Attempts to eliminate plastic shrinkage cracking by modifying the concrete mixture composition to affect bleeding characteristics 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, such as:

- Have proper manpower, equipment and supplies on hand so that the concrete can be placed and finished properly. 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 before floating or troweling.
- Erect temporary windbreaks to reduce the wind velocity over the surface of the concrete and, if possible, erect sunshades to control the surface temperature of the slab when adverse conditions exist. If conditions are critical, schedule placement to occur later in the afternoon or early evening. However, in very hot conditions, early morning placement might afford better control of concrete temperatures.
- In very hot, dry periods, the use fog sprays to discharge a fine mist upwind and into the air above the concrete. Fog sprays reduce the rate of evaporation of the concrete surface and should continue until suitable curing materials can be applied.
- If concrete is to be placed on a dry absorbative surface such as subgrade, granular base or a previously placed concrete, dampen them, including the formwork and reinforcement, but not to the point in which free standing water exists, prior to placement.
- The use of vapour barriers under a slab-on-grade can increase the risk of plastic shrinkage cracking. However, they may be necessary for interior slabs that may have a floor covering at any point during its service life.
- Consider using synthetic fibers to minimize plastic shrinkage cracking.
- Start curing the concrete as soon as possible. Cover the surface with wet burlap or other moisture retaining material, keeping it continuously moist for a minimum of 3 days, or use a liquid membrane curing compound.
- Accelerate the setting time of concrete and avoid large temperature differences between concrete and ambient air temperatures.

FOLLOW these rules to minimize plastic shrinkage cracking:

- Dampen all surfaces prior to concrete placement.
- Prevent excessive surface moisture evaporation by providing fog sprays and erecting windbreaks.
- Cover concrete with wet burlap or polyethylene sheets between finishing operations.
- Use cooler concrete in hot weather and avoid high concrete temperatures in cold weather.
- Cure properly as soon as finishing has been completed.

References:

1. Guide for Concrete Floor and Slab Construction, ACI 302.1R, American Concrete Institute, Farmington Hills, MI.
2. Hot Weather Concreting, ACI 305R, American Concrete Institute, Farmington Hills, MI.
3. Standard Practice for Curing Concrete, ACI 308, American Concrete Institute, Farmington Hills, MI.
4. CIP 5: Plastic Shrinkage Cracking, National Ready-Mixed Concrete Association
5. CAN CSA A23.1-24/A23.2-24.