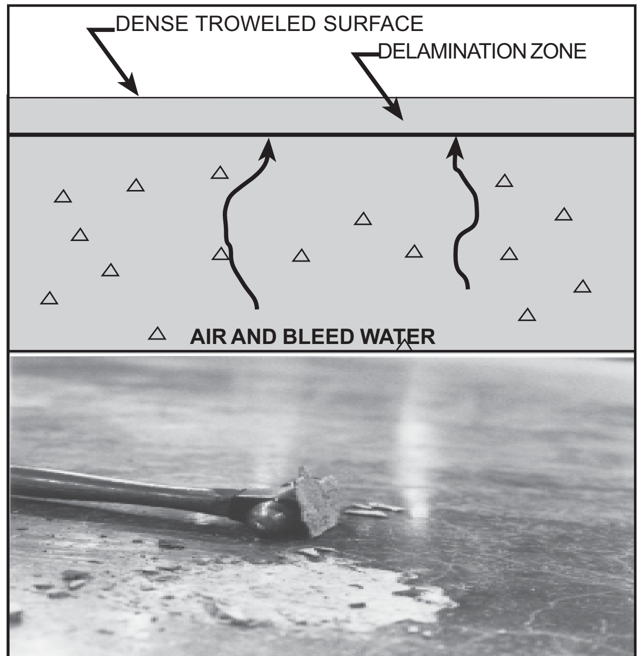
Concrete in Practice

What, why & how?

NRMCA

CIP 20 - Delamination of Troweled Concrete Surfaces



Delaminated Concrete

WHAT are Delaminations?

In most delaminated concrete slab surfaces, the top 1/8 to ¼ inch (3 to 6 mm) is densified, primarily due to premature and improper finishing, and separated from the base slab by a thin layer of air or water. The delaminations on the surface of a slab may range in size from several square inches to many square feet. The concrete slab surface may exhibit cracking and color differences because of rapid drying of the thin surface during curing. Traffic or freezing may break away the surface in large sheets. Delaminations are similar to blisters, but much larger (see CIP 13).

Delaminations form during final troweling. They are more frequent in early spring and late fall when concrete is placed on a cool subgrade with rising daytime temperatures, but they can occur at anytime depending on the concrete characteristics and the finishing practices used.

Corrosion of reinforcing steel near the concrete surface or poor bond between two-course placements may also cause delaminations (or spalling). The resulting delaminations are generally thicker than those caused by improper finishing.

Delaminations are difficult to detect during finishing but become evident after the concrete surface has set and dried. Delaminations can be detected by a hollow sound when tapped with a hammer or with a heavy chain drag. A procedure is described in ASTM D 4580, *Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding*. More sophisticated techniques include acoustic impact echo and ground-penetrating radar.

WHY does Delamination Occur?

Bleeding is the upward flow of mixing water in plastic concrete as a result of the settlement of the solids. Delamination occurs when the fresh concrete surface is sealed or densified by troweling while the underlying concrete is still plastic and continues to bleed and/or to release air. Delaminations form fairly late in the finishing process after floating and after the first troweling pass. They can, however, form during the floating operation if the surface is overworked and densified. The chances for delaminations are greatly increased when conditions promote rapid drying of the surface (wind, sun, or low humidity). Drying and higher temperature at the slab surface makes it appear ready to trowel while the underlying concrete is plastic and can still bleed or release air. Vapor retarders placed directly under slabs force bleed water to rise and compound the problem.

Factors that delay initial set of the concrete and reduce the rate of bleeding will increase the chances for delaminations. Entrained air in concrete reduces the rate of bleeding and promotes early finishing that will produce a dense impermeable surface layer. A cool subgrade delays set in the bottom relative to the top layer.

Delamination is more likely to form if:

1. The underlying concrete sets slowly because of a cool subgrade.
2. The setting of the concrete is retarded due to con-

crete temperature or mixture ingredients.

3. The concrete has entrained air or the air content is higher than desirable for the application.
4. The concrete mixture is sticky from higher cementitious material or sand-fines content.
5. Environmental conditions during placement are conducive to rapid drying causing the surface to "crust" and appear ready to finish.
6. Concrete is excessively consolidated, such as the use of a jitterbug or vibrating screed that brings too much mortar to the surface.
7. A dry shake is used, particularly with air-entrained concrete.
8. The slab is thick.
9. The slab is placed directly on a vapor retarder.

Corrosion-related delaminations are formed when the upper layer of reinforcing steel rusts thereby breaking the bond between the steel and the surrounding concrete. Corrosion of steel occurs with reduced concrete cover and when the concrete is relatively more permeable causing chlorides to penetrate to the layer of the steel (See CIP 25).

HOW to Prevent Delamination?

Accelerators or heated concrete often prevent delamination in cool weather.

Be wary of a concrete surface that appears to be ready to trowel before it would normally be expected. Emphasis in finishing should be on screeding, straight-edging, and floating the concrete as rapidly as possible—without working up an excessive layer of mortar and without sealing the surface layer. In initial floating, the float blades should be flat to avoid densifying the surface too early.

Final finishing operations to produce a smooth surface should be delayed as long as possible, and the surface covered with polyethylene or otherwise protected from evaporation.

Delamination may be difficult to detect during finishing operations. If delamination is observed, tear the surface with a wood float and delay finishing as long as possible. Any steps that can be taken to slow evaporation should help.

If a vapor retarder is required, place at least four inches (100 mm) of a trimable, compactible granular fill (not sand). Do not place concrete directly on a vapor retarder. If a moisture-sensitive floor covering will be placed on interior slabs, concrete will generally be placed directly on a vapor retarder (see CIP 29), and other procedures may be necessary.

Do not use air-entrained concrete for interior floor slabs that have a hard troweled surface and that will not be subject to freeze-thaw cycles or deicing salt application. If entrained air is necessary to protect interior slabs from freezing and thawing cycles during construction avoid using air contents over 3%.

Delaminated surfaces can be repaired by patching after the surface layer is removed and the underlaying concrete is properly cleaned. Extensive delamination may need to be repaired by grinding and overlaying a new surface. Delaminated surfaces due to steel corrosion will additionally require sandblasting to remove rust from the steel.

References

1. *Guide for Concrete Floor and Slab Construction*, ACI 302.1R American Concrete Institute, Farmington Hills, MI www.concrete.org
2. *Slabs on Grade*, ACI Concrete Craftsman Series, American Concrete Institute, Farmington Hills, MI.
3. *Concrete Slab Surface Defects: Causes, Prevention, Repair*, IS177, Portland Cement Association, Skokie, IL, www.cement.org
4. *Diagnosing Slab Delaminations – Series in three parts,* B. Suprenant, Concrete Construction, January, February and March 1998, www.worldofconcrete.com.
5. *Using the Right Finishing Tool at the Right Time*, R.H. Spannenberg, Concrete Construction, May 1996.
6. *Concrete in Practice Series*, NRMCA, Silver Spring, Maryland, www.nrmca.org.
7. *Residential Concrete*, National Association of Home Builders, Washington, DC, www.nahb.com.
8. *ASTM D 4580*, Annual Book of ASTM Standards, Vol 04.03, ASTM International, West Conshohocken, PA, www.astm.org.

Follow These Rules to Avoid Delamination

1. Do not seal surface early—before air or bleed water from below have escaped.
2. Avoid dry shakes on air-entrained concrete.
3. Use heated or accelerated concrete to promote even setting throughout slab depth.
4. Avoid placing concrete directly on vapor retarders, if the application allows.
5. Do not use air-entrained concrete for interior slabs that will receive a trowel finish.
6. Avoid placing concrete on substrate with a temperature of less than 40° F (4° C).

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