

Concrete in Practice

What, why & how?



CIP 20 - Delamination of Troweled Concrete Surfaces

WHAT are Delaminations

Delaminations are separations of thin layers of the slab surface from the base concrete. Delamination typically results in break off of surface layers, 1/8 to 1/4 inch (3 to 6 mm) in thickness, from a finished slab. These are primarily caused when the concrete mixture and construction conditions result in premature or excessive finishing whereby the slab surface is densified and traps air and bleed water beneath the densified layer. Delaminations can vary in size from a few square inches to many square feet. Delaminations are similar to blisters, but much larger (CIP 13).

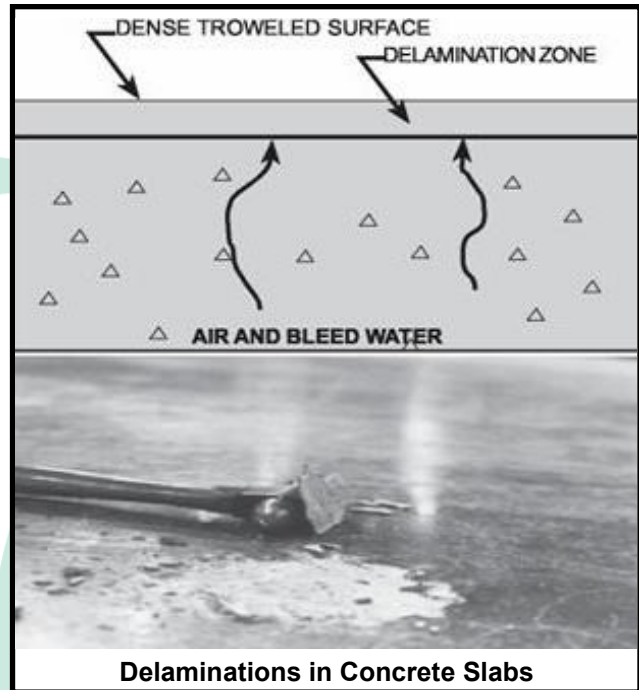
Delaminations are more commonly seen in hard-troweled floor slabs and occur if final troweling is performed when the surface appears to have stiffened sufficiently but concrete is continuing to bleed. Delaminations can also occur with other finishing methods with excessive and premature finishing that densifies the surface.

Corrosion of reinforcing steel near the concrete surface or poor bond between two-course placements may also cause delaminations (or spalling). These typically result in thicker surface separations.

Delaminations are difficult to detect during finishing but become evident after the concrete surface has set. The concrete slab surface may exhibit cracking and color differences as thinner surfaces dry faster than sound concrete. On a finished slab, delaminations can be detected by a hollow sound when tapped with a hammer or with a heavy chain drag. Such procedures are described in ASTM D4580. 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 solids settle. Delamination occurs when the concrete slab surface is sealed or densified by troweling or excessive finishing when the slab surface appears to have stiffened but 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 stiffening of the surface (wind, sun, or low humidity). Placing concrete on a cold subgrade can cause top-down stiffening. Placing concrete on an impermeable subgrade or a vapor retarder will increase the quantity of bleed water and the duration of bleeding. In general, factors that impact the capacity, rate, and duration of bleeding relative to setting characteristics of concrete; and conditions that cause the slab surface to stiffen indicating its ready to finish will increase the potential for delaminations to form.

Factors that affect bleeding include:

- Entrained air
- Higher quantities of cementitious materials
- Fly ash, slag cement, and aggregate fines
- High mixing water content in concrete
- Slab thickness
- Cold subgrade
- Impermeable subgrade
- Vapor retarder directly under slab

Factors that affect surface stiffening include:

- High wind velocity
- Low relative humidity
- Rising ambient temperature
- Exposure to direct sunlight
- Concrete mixture composition resulting in retarded setting time
- Cooler concrete temperature

Excessive consolidation of a slab, such as the use of a jitterbug or vibrating screed, that brings too much mortar to the surface can cause delaminations.

A dry shake applied improperly, especially with air-entrained concrete can result in problems.

Corrosion-related delamination is typical with less clear cover to reinforcing steel. Formation of rust expands and spalls off the cover concrete. Corrosion of steel occurs when the concrete is relatively more permeable causing chlorides to penetrate to the layer of the steel (See CIP 25).

HOW to Prevent Delamination

Concrete delivered with a higher temperature and accelerating admixtures can prevent delamination in cool weather.

Finishing operations like screeding, straight-edging, and floating should be done as rapidly as possible without working up an excessive layer of mortar and without sealing the surface layer. A slab without bleed water on the surface may not be ready to trowel. Typically a 1/4-in. indentation of a boot is used to determine that the concrete has stiffened sufficiently to begin trowelling. Penetrate the surface with a sharp object to ensure the underlying concrete is not plastic.

For initial floating, the 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; minimize evaporation by covering the surface with polyethylene or using evaporation retarders. A surface that tears during troweling may not be ready to finish.

Vapor retarders are required to be directly under the slab if a floor covering is to be installed. This increases the capacity and duration of bleeding. If a floor covering will not be installed, place at least 4 in. (100 mm) of a trimable, compactible granular fill (not sand) over the vapor retarder to reduce bleeding.

Entrained air in concrete has a significant effect on the rate of bleeding of concrete mixtures. It can result in premature finishing when the bleed water sheen disappears before concrete has adequately set but concrete continues to bleed. Air entrained concrete should not be specified for floor slabs that will receive a hard troweled finish as it increases the potential for delaminations. The risk of damage due to exposure to freezing and thawing cycles during construction is considerably less than the potential for causing delaminations. A maximum air content of 3% is recommended for troweled floor slabs.

Delaminated surfaces can be repaired by patching after the surface layer is removed and the underlying 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

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3. *Concrete Floors on Ground*, EB075, Portland Cement Association, Skokie, IL. www.cement.org.
4. *Diagnosing Slab Delaminations – Series in three parts*, B.S. Suprenant and W.R. Malisch, Concrete Construction, January, February and March 1998, www.concreteconstruction.net.
5. *Using the Right Finishing Tool at the Right Time*, R.H. Spannenberg, Concrete Construction, May 1996.
6. *Sealing Effects of Finishing Tools*, Suprenant, B.A., Malisch, W.R., Concrete Construction, September 1999. www.concreteconstruction.net.
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Follow These Rules to Avoid Delamination

1. Do not over consolidate and seal surface early—before air or bleed water from below have escaped.
2. Avoid dry shakes on air-entrained concrete.
3. Use higher temperature concrete or accelerating admixtures to promote even setting throughout slab depth.
4. Avoid placing concrete directly on vapor retarders or impermeable subgrade, if the application allows.
5. Do not use air-entrained concrete for 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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