

Concrete in Practice

What, why & how?



CIP 2 - Scaling Concrete Surfaces

WHAT is Scaling

Scaling is local flaking or peeling of a finished surface of hardened concrete as a result of exposure to cycles of freezing and thawing. Generally, it starts as localized small patches which later may merge and extend to expose large areas. Light scaling does not expose the coarse aggregate. Moderate scaling exposes the aggregate and may involve loss of up to $\frac{1}{8}$ to $\frac{3}{8}$ inch [3 to 10 mm] of the surface mortar. In severe scaling more surface has been lost and the aggregate is clearly exposed and stands out.

Note—Occasionally concrete peels or scales in the absence of freezing and thawing. This type of scaling is not covered in this CIP. Often this is due to the early use of a steel trowel, over-finishing or finishing while bleed water is on the surface.

WHY Do Concrete Surfaces Scale

Concrete slabs and surfaces of other members that are saturated with water and exposed to cycles of freezing and thawing are susceptible to scaling. When concrete is saturated with water and temperature approaches freezing, water expands as it forms ice and this causes stresses within concrete. As the number of cycles of freezing and thawing increases, the potential for scaling increases. Deicing chemicals exacerbate this by increasing the saturation of concrete at the surface and the number of freezing and thawing cycles. Air entrained concrete contains millions of small air bubbles that accommodate the expanding water and ice and prevent the stress buildup.

Most scaling is caused by:

- The use of *non-air-entrained concrete* or too little entrained air, especially at the surface.
- Using concrete that has a low strength that allows permeation to water.
- Using the improper concrete mixture or mixture proportions for the application.
- Application of excessive amounts of deicing chemicals, especially on newly installed concrete that tends to be saturated and of lower strength.
- Improper finishing procedures of concrete slabs.
- Insufficient curing resulting in a weak concrete surface.

HOW to Prevent Scaling

The potential for scaling in concrete slabs can be reduced by using good quality dense concrete with entrained air, following good practice for installing and curing, and by minimizing the use of deicing chemicals.



Scaling on Concrete Slab

For concrete that will be continuously moist, exposed to freezing temperatures and will be subject to the use of deicing chemicals, the following recommendations should be followed:

- For exterior slabs, order concrete with specified strength of 4000 psi [28 MPa], consistent with the requirements of ACI 332, *Code for Residential Concrete*. For concrete that will not be continuously moist or where deicing chemicals will not be applied, the specified strength should be 3500 psi [24 MPa].
- Concrete should be air-entrained. The recommended total air content for concrete containing $\frac{3}{4}$ -inch [19 mm] or 1-inch [25 mm] coarse aggregate is 6 percent.
- The quantity of supplementary cementitious materials (SCM) should not exceed one of the following: 25% fly ash, 50% slag cement or 10% silica fume, expressed as percent by weight of the cementitious materials. SCMs are beneficial to concrete, however, at higher quantities change the rate of setting, bleeding, and strength gain. These impact the process of finishing. With appropriate modifications of the finishing procedures, it is possible to use higher quantities of SCMs, but these need to be evaluated.
- For most slab construction, place concrete at a slump in the range of 3 to 5 inches [75 to 125 mm]. Do not add excessive water at the jobsite. High slump obtained by adding water increased the potential for segregation and excessive bleeding and can result in weak mortar layer at the surface. Water reducing admixtures can provide improved workability and retain good concrete quality.
- Placing and finishing procedures can reduce the entrained air content in concrete, making it more susceptible to scaling.
- Do not use a jitterbug or vibrating screed with high

slump concrete as it increases segregation and result in a weak mortar layer at the surface.

- g. Do not perform finishing operations with bleed water present on the surface. Bull floating must promptly follow initial screeding. Delay subsequent finishing until bleed water has risen and dissipated from the surface. This is critical when placing air-entrained concrete in dry and windy conditions where the surface may appear to be dry while concrete is continuing to bleed. The use of fog sprays or evaporation retardants are recommended in these conditions. See CIP 14 for finishing concrete.
- h. Do not overwork the surface of concrete. Excessive finishing reduces entrained air in the surface layer. For most exterior surfaces a broom finish is adequate.
- i. Provide proper curing by using pigmented liquid membrane curing compound or by covering the surface of newly placed slab with wet burlap and plastic sheets. Proper curing involves maintaining concrete at adequate temperature and moisture for optimum performance.
- j. Protect concrete from the harsh winter environment. Apply a commercially available silane or siloxane-based breathable concrete sealer or water repellent specifically designed for use on concrete slabs. Follow the manufacturer's recommendations. The concrete should be reasonably dry prior to the application of a sealer. Late summer with a few dry days preceding application is an ideal time.
- k. Be cautious about placing exterior concrete in late fall, winter or early spring when conditions are such that it will be exposed to freezing temperatures shortly after placement while concrete is still saturated.
- l. Avoid using deicing chemicals on newly placed concrete, if possible. Use clean sand for traction. When used, deicing chemicals should be applied in moderate amounts. Excessive applications increases potential for scaling. When conditions permit, hose off accumulation of salt deposited by cars on driveways and garage slabs. Deicing chemicals composed of calcium chloride and sodium chloride (rock salt) are considered acceptable for concrete. Never use ammonium sulfate or ammonium nitrate or magnesium-based salts as a deicer; these are

chemically aggressive and destroy concrete surfaces. Magnesium-based salts are used for pre-snow deicing of roads and can be tracked by cars and accumulate on concrete surfaces. Poor drainage causing salt solutions to accumulate on concrete surfaces increases the severity of the exposure and may cause scaling.

HOW to Repair Scaled Surfaces

Minor scaling is a cosmetic issue and may not need to be repaired. On the other hand repairing concrete slabs with excessive and progressing scaling may not be feasible.

It is possible to repair light to moderately scaled surfaces. The repaired surface will only be as strong as the base surface to which it is bonded. The surface should be prepared to remove the unsound surface and should be free of dirt, oil or paint. The surface receiving the repair must be sound. To accomplish this, use a hammer and chisel, sandblasting, high-pressure washer, or jack hammer. The clean, rough, textured surface can be repaired with thin bonded resurfacing such as:

- a. Portland cement concrete resurfacing
- b. Latex modified concrete resurfacing
- c. Polymer-modified cementitious-based repair mortar

Repair material will not match the color and characteristics of the original concrete.

References

1. *Guide to Durable Concrete*, ACI 201.2R, American Concrete Institute, Farmington Hills, MI.
2. *Scale-Resistant Concrete Pavements*, IS117.02P, Portland Cement Association, Skokie, IL.
3. *Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals*, National Cooperative Highway Research Program Report No. 16.
4. *Code Requirements for Residential Concrete*, ACI 332, American Concrete Institute, Farmington Hills, MI.
5. *Residential Concrete*, National Association of Home Builders, Washington, DC.
6. *Slabs on Grade*, Concrete Craftsman Series CCS-1, American Concrete Institute, Farmington Hills, MI.
7. Eugene Goeb, *Deicer Scaling: An Unnecessary Problem*, Concrete Products, February 1994.
8. *Concrete in Practice Series*, CIP 5, 11, 14, NRMCA, Silver Spring, MD.

Follow These Rules to Prevent Scaling

1. For concrete that will be exposed to severe freezing and thawing conditions order good quality air-entrained concrete with a strength of 4000 psi [28 MPa]
2. Do not add excessive water and place concrete at a slump of 3 to 5 inches [75 to 125 mm].
3. Finish concrete after bleed water has dissipated and avoid using steel trowels when finishing.
4. Properly cure the concrete
5. Consider sealing the surface with a commercial breathable sealer.
6. Avoid the use of deicing chemicals in the first winter and subsequently use them in moderate amounts.

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