

scaling

Definition

ACI 116 defines scaling as "local flaking or peeling away of the near surface portion of hardened concrete..."

ACI further defines various degrees of scaling:

- Light Scaling is defined as a condition that does not expose coarse aggregate.
- Medium Scaling is the loss of surface mortar, 5 to 10 mm in depth, with exposure of aggregate
- Severe Scaling is a loss of surface mortar 5 to 10 mm in depth, with a loss of some mortar surrounding the aggregate particles, 10 to 20 mm in depth.
- Very Severe Scaling is the loss of coarse aggregate as well as mortar, generally greater than 20 mm in depth.

Discussion

Scaling occurs when water saturated concrete experiences freezing and thawing cycles. As water goes from a liquid to solid form (freezes), its volume will expand by 9%. All concretes have a structure of channels, pores, and voids which in wet environments, will fill with water. When the concrete temperature drops below 32 degrees F, this water expansion takes place within the concrete. If the concrete was not properly designed and placed to withstand this occurrence, internal pressures will exceed the concrete tensile strengths and scaling will occur.

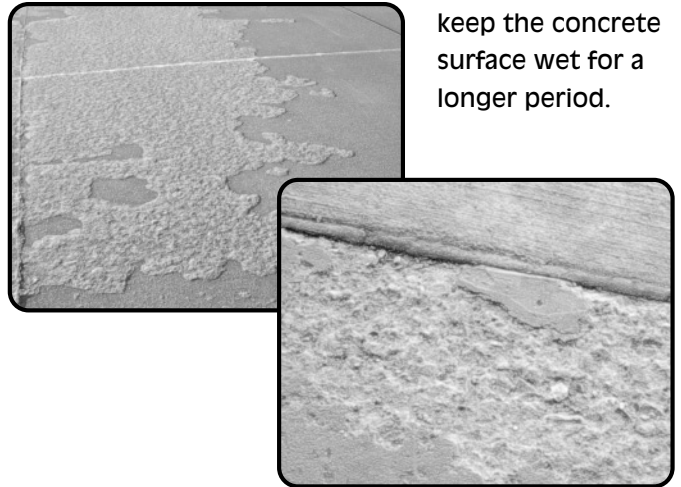
We know how to make concrete resistant to scaling, but it takes a combined effort on the part of the ready mix producer, contractor, and owner. The problem usually boils down to cost. The remedies to prevent scaling add to the cost of concrete placement.

Causes of Scaling

1. Detrimental actions of deicing chemicals and severe cycles of freezing and thawing. Chemicals used for melting snow and ice aggravate surface scaling. Their problem is two fold;

- a. the freezing point of water is lowered resulting in additional freeze thaw cycles and,
- b. salts, commonly present in these de-icers,

absorb water and keep the concrete surface wet for a longer period.



2. Improper finishing and workmanship. Resistance to scaling is most needed at the surface exposed to weather elements. It is this same surface which is most abused during placement. Working bleed water or adding water to the surface to aid in finishing makes the concrete surface weaker and destroys the air void system. Over-working the surface may not add water, but will also destroy the entrained air system.

3. Improper curing. Curing is critical to maximize concrete durability (see curing). Concrete which is not allowed to properly cure, will have a lower compressive strength, be more absorptive, and more susceptible to scaling.

4. Unsound aggregates. Aggregates with high percentage of unsound particles will cause excessive popouts, and lead to progressive scaling.

Prevention of Scaling

■ Air Entrainment

Properly sized and spaced air voids within the concrete are critical in producing scale-resistant concrete. In normal concretes, this is usually measured as 6% of total volume. While having air entrained concrete does not guarantee against scaling, non-air entrained concrete will most certainly experience scaling in a wet, freeze-thaw environment. Further guidance on proper air content can be found in ACI 318, "Building Code Requirements for Reinforced Concrete."

■ Finishing

Minimize "working" the surface of exterior, air-entrained concrete. Do not work water, from any source, into the surface. Protect the plastic concrete during placement from additional water or premature drying.

■ Aggregates

Fine and coarse aggregates should meet the requirements of ASTM C 33.

■ Maximum Water-Cementitious Ratio

Concrete exposed to freeze-thaw cycles should not exceed a water-cement ratio of 0.45. With a normal water reducer included in the mix, this equates to approximately 4-inch slump. The likelihood of scaling increases dramatically as the w/c ratio increases. If higher slump mix is necessary, use a mid-range water reducer.

■ Adequate Strength and Drying

ACI 318 specifies a minimum compressive design strength of 4500 psi for concrete exposed to freeze-thaw in a moist environment, or deicing chemicals. Like air entrainment, however, meeting 4500 psi does not guarantee freeze-thaw durability. After adequate cure time, a period (one month) of air-drying will increase the durability of concrete exposed to freeze-thaw conditions.

■ Curing

Curing is essential to ensure a durable surface. Curing should begin as soon as the surface will allow (will not mar), and should continue till the concrete has achieved not less than 70% of the specified compressive or flexural strength. Curing should be as long as practical, by the most practical method (see curing). Not curing concrete can reduce compressive strength by as much as 50%.

■ Late Season Exterior Concrete

Extra care and caution should be taken for late season, exterior concrete placement. Shorter hours of sunlight and cooler nighttime temperatures will severely effect strength gain in the concrete. Added to the potentially lower strength is the fact that the concrete will be saturated with water and incimate weather will soon bring freezing temperatures, snow, ice, and deicing materials. Attempts to keep de-icers off the new slab are useless as cars carry salts off city streets onto the new concrete. Late season, exterior concrete mix designs should be modified to include the following:

- a. lower the w/c ratio by using a mid-range water reducer at a moderate dosage, and,
- b. use liquid accelerators (chloride if acceptable, else non-chloride) at higher dosages to reach design strengths early, extend drying period.

References

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NRMCA, Concrete in Practice #2, 1998

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Master Builders, Inc., concrete Technology Update,
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Scaling Revisited,
David Lankard, Concrete International, May 2001