CONCRETE INFORMATION

Scale-Resistant Concrete Pavements

Over five decades of field service experience and extensive laboratory testing have shown that properly air-entrained concrete has excellent resistance to surface scaling due to freezing and thawing and the use of common deicing chemicals. Service records and laboratory tests have also shown that scaling is primarily a physical action. It is not caused by chemical reactions* or crystal pressures.

Deicer scaling of inadequately air-entrained or non-air-entrained concrete is caused by hydraulic and osmotic pressures. The presence of a deicer solution in concrete will cause a high degree of saturation in the concrete material itself. Subsequently, during freezing periods the build-up of pressures accelerate to the point that these pressures become critical and scaling will result when entrained air voids are not present to act as relief valves.

The degree of benefit provided by air entrainment is largely dependent upon the size and spacing of the air voids. Small, closely spaced voids prevent the hydraulic pressures from building up to a level sufficient to cause scaling.

Proper attention to design and construction will ensure scale-resistant concrete pavements. The following practices are required for all areas where pavements are subjected to freezing and thawing and the application of deicing materials:

1. Strict adherence to the fundamentals of quality concrete
2. Adequate curing
3. A period of air drying

Fundamentals of Quality Concrete

Deicer-scaling resistance of concrete is greatly improved when these fundamentals are followed:

1. Minimum cement content—564 lb per cubic yard (335 kg per cubic meter)
2. Maximum water-cementitious material ratio—0.45
3. Low slump—not more than 4 in. (100 mm) (unless a water-reducer is used)
4. Sound, clean, durable, well-graded aggregates
5. Adequate air void system
6. Proper proportioning, mixing, placing, and finishing

The use of entrained air in a concrete mixture must be closely monitored. An insufficient amount of entrained air will not properly protect the concrete pavement from damage caused by freeze-thaw effects. In addition, if too much air is used, the strengths of the concrete will be lessened to an unacceptable level. Recommended air contents of concrete are given below.

See PCA publication *Design and Control of Concrete Mixtures* for additional details.

Maximum size aggregate, in.	Total target air content, percent*	
	Severe Exposure	Moderate Exposure
3/8 (9.5 mm)	7-1/2	6
1/2 (12.5 mm)	7	5-1/2
3/4 (19.0 mm)	6	5
1 (25.0 mm)	6	4-1/2
1-1/2 (37.5 mm)	5-1/2	4-1/2
2 (50.0 mm)	5	4

* Many specifications allow for tolerance of −1 to +2 percentage points of the target value during field construction.

Curing

Concrete pavements have a high ratio of exposed surface area to volume of concrete. Proper curing procedures and durations must be strictly adhered to in order to ensure adequate strength and durable scale-resistant concrete. Curing procedures should begin as soon as possible after the finishing operations are complete and as soon as marring of the pavement surface will not occur.

Clear or white pigmented liquid-membrane curing compounds, waterproof paper, plastic covers, polyethylene sheets, and dampened burlap or cotton mats are all acceptable methods for curing concrete. For concrete pavements, the liquid-membrane curing compounds are most commonly used because of convenience and cost effectiveness. The curing compounds should be applied after the water film has evaporated from the surface.

ACI Manual of Concrete Practice, ACI 308 Curing Concrete recommends the following curing period for pavements and other slabs on the ground:

* Ammonium nitrate and ammonium sulfate fertilizers have been sold as deicers. These materials in the presence of water react chemically with all forms of concrete and cause objectionable disintegration —even at room temperatures. Their use must be strictly prohibited.

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For daily mean ambient temperatures above 40° F (5° C) the recommended minimum period of maintenance of moisture and temperature for all procedures is 7 days or the time necessary to attain 70 percent of the specified compressive or flexural strength, whichever period is less.

In some instances, accelerating admixtures are added to concrete mixtures using Type I and Type II cement to speed up strength gain to meet curing criteria. High early strength cement (Type III) or other proprietary cements can be used for this same purpose.

Insulated curing blankets, or other means, can be used to ensure that the concrete pavement's temperature and moisture conditions remain favorable for proper curing during colder periods (40° F (5° C) or lower).

Air Drying

Field experience substantiates laboratory studies which show that after curing, a period of air drying greatly increases the resistance of air-entrained concrete to deicers. Pavements may be opened to traffic during an air-drying period if no deicing chemicals will be required during this period. Pavements placed in the spring or summer have drying periods in the normal course of aging. Pavements placed in the fall season, however, often may not dry out enough before the use of deicing agents becomes necessary. This is especially true of fall paving cured by membrane-forming compounds. These membranes remain intact until worn off by traffic, and thus adequate drying may not occur before the onset of winter. Curing methods that allow drying at the completion of the curing period are preferable for fall paving on all projects where deicers will be used.

The required time for sufficient drying to take place cannot be pinpointed due to variations in climate and weather conditions. In general, the use of deicers is not recommended earlier than 30 days after the proper curing period. Favorable experience in some severe climate areas has shown however that concrete with a water-cement ratio of 0.40 or less, can be exposed to deicers somewhat earlier.

Surface Treatments

Surface treatments are not needed on good quality concrete. If surface scaling should develop during the first frost season, a surface treatment may be used to help protect the concrete against further damage. These treatments are usually breathable formulations made with linseed oil, siloxane/silane water repellents, or other suitable materials.

Linseed oil treatments consist of equal parts of commercial boiled linseed oil and a solvent such as turpentine, naphtha, or mineral spirits. Recommended linseed oil coverages are about 40 to 50 sq yd per gallon (9 to 11 m^2 per liter) for the first application and about 70 sq yd per gallon (15 m^2 per liter) for the second application. If possible, pavement temperatures should be about 50° F (10° C) or above at the time of application to assure proper penetration and to hasten drying. Since oil treatments will produce a slippery surface until absorbed, it may be necessary to keep traffic off the pavement until sufficient drying has taken place. Each application should be absorbed within approximately one hour if favorable weather conditions prevail.

When using the linseed oil mixture described, a slight darkening of the concrete surface will occur. This effect on the pavement's appearance may not be acceptable, in which case other materials may be used. As with any product, these sealers should be applied in accordance with the manufacturers' instructions. The cost of protective treatments will vary according to the type of treatment and the amount of pavement treated.

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