GUIDELINES FOR DEICING EFFECTS

A Guide for Deicing Salts and the Effect on Concrete Surfaces

8329 Monticello Road, Shawnee, KS 66227 ♦ Tel: (913) 422-4443 ♦ Fax: (913) 422-8882
Website: www.murraydecorative.com ♦ Email: info@murraydecorative.com

Good concrete can be adversely affected by the use of chemicals, especially deicing salts and fertilizers. Even properly placed concrete, concrete with low water-cement ratios, and properly cured concrete is often affected by the use of these chemicals. Because of this, neither deicing salts nor fertilizers should be used on the concrete for the first year after placement. Unfortunately, however, we all know cities use salts and chemicals faster than they should. These chemicals can be tracked-in by vehicles or even people walking. The chemicals can be picked up by tires, boots and undercarriages of vehicles and can be released back onto concrete surfaces. Care should be taken to properly protect concrete. If weather allows, inform snow removal contractors to remove as much of the snow and ice as possible and to not just let it melt away. It is too often the practice of such contractors to remove the minimum amount of snow and ice and over salt so as to quickly move onto their next job.

For one to understand the significant damaging effects of salts and freeze-thaw cycles on concrete, it is first important to understand the nature of concrete and how it becomes hard or cures. Concrete is made with four basic components: water, cement, fine aggregate and coarse aggregate. The water and cement become a paste which, in turn, reacts with the fine and coarse aggregates to form the hard material we call concrete. The curing process comes from a chemical process called hydration. This chemical reaction requires the cement and water to combine. As the cement and water combine the chemical compounds also interact with the aggregates. When combined properly there is minimal spacing between the aggregates. The gradation of the aggregates is important for the durability of the concrete. By using several sizes of aggregate, the voids in the concrete mix are filled with aggregate.

The cement or binder is made from limestone and clay. These materials are crushed, ground and then heated to 3,000°F. This process creates several new compounds that form the cement, including:

- Tricalcium silicate - 50%
- Dicalicum silicate - 25%
- Tricalcium aluminate - 10%
- Tetraclaium aluminoferrite - 10%
- Gypsum (to control setting) - 5%

Heat is generated as this reaction begins:

Tricalcium silicate + water = calcium silicate hydrate + calcium hydroxide + heat

As the four basic components are combined in the concrete mix and the hydration process begins, much of the mixing water is used in the process. The mixing water that is not used in this process is left and creates small voids in the concrete. In the end, the less amount of voids, the better the concrete. The ratio of water to cement is commonly referred to as the water-cement ratio. The lower the water-cement ratio, the stronger the concrete will be. Lower water-cement ratio results in a lower porosity. This means that

There are fewer voids for both water and chemicals to enter into the concrete increasing the durability of the concrete.

One way to think of concrete is to imagine the grains of cement as small arms and legs that lock on to the aggregates. The shorter the distance between the grains of cement and the aggregates (the less voids), the stronger the concrete will be. Just as a child needs time to grow and become healthy and strong, concrete needs proper time to cure and gain strength and durability? As the reaction begins to take place, the paste (the cement and water) lock onto the aggregates to create the rock-hard mass we call concrete. Unfortunately, many think that the next day when the concrete is hard, it's done. This is simply not the case. Hydration is a growing phase, much like when children grow up. Children need to take their vitamins, eat properly, and exercise so they become healthy and strong. This takes years. Concrete hydration is very similar. It is dependent on several things is ensure good concrete. The water used in the mix leaves over time but the longer the water stays in the mix, the stronger the concrete becomes. This process is referred to as the curing time. Most concrete mixes achieve over 75% of its desired strength in the first 28 days.

Curing is defined as controlling the moisture loss in the early stages of hydration. It is important to control temperature during this time as well. For example, on hot, windy days the moisture in the concrete can leave much too quickly. In addition, in cold weather, the concrete needs protection from the freezing temperatures. When water is allowed to enter concrete and freeze it will expand 9%. While the concrete is curing, protection of the concrete is vital. The following are some set-time guidelines based on the air temperature:

Temperature	**Set Time**
90 °F	3 Hours
80 °F	4 Hours
70 °F	5 Hours
60 °F	9 Hours
50 °F	13 Hours

One major problem seen is the housing industry, is the failure to properly understand concrete hydration. This results in concrete being put into service too soon which greatly affects the concrete's strength and durability properties. Another major problem seen in housing is early use of power washers to clean the concrete surface. The use of power washers forces water into the concrete's surface at a high power. During the early stages of hydration, power washers should never be used. Power washers can be used after the concrete is at least 14 days old. Barricades are many times quickly removed by other contractors and the concrete is opened for service too soon. Foot traffic is usually fine within a day after casting, but vehicular traffic should wait a minimum of 7 days. During snow or ice cycles, the sub-contractors should never be allowed on the concrete until such time that it is turned over to the owner.

Note: Newly fresh placed concrete should never be allowed to freeze until it has achieved a minimum strength of 500 lbs per square foot. This normally takes between 36 and 52 hours. If the new concrete is exposed to moisture, like rain, it should achieve strength of 3,500 lbs per square foot. This may take anywhere from 14 to 28 days.

The aggregate is a large volume of the concrete mix. This portion is like a child's bones. They need to be both healthy and strong. Hard, clean, sound aggregates are the key to the concrete's growth and life cycle. Unfortunately, many fail to upgrade aggregates when designing a concrete mix. The short term price becomes the primary deciding factor and long-term durability is neglected. Lower priced mixes might seem good at the bid or to make budget, but one also needs to realize that choosing better aggregates will result in concrete that will satisfy the performance requirements, withstand exposed weather conditions and provide years of service. Using clean, hard aggregates with an optimized aggregate gradation in concrete mixes not only gives increased durability but also will reduce labor and maintenance costs, while increasing life/cycle costs.

A generic mix design is as follows:

- Cement 11%
- Water 15%
- Fine aggregate 26 %
- Course aggregate 41 %
- Admixtures (air entraining) 6-8%

There are certain keywords in mix-designs that need to be understood. The first and most important for concrete exposed to freezing (especially repeated freezing cycles) is air entraining admixtures.

Air entrainment is an admixture added to all exterior concrete. It creates millions of microscopic bubbles in the concrete. These bubbles act as a relief valve to withstand the pressures of internal water freezing. Most concrete mixes allow for 8% of air and a place for the water to expand. Two types of air are found in concrete mixes: air that is created from normal mixing and air from air entrainment admixtures. The normal mixing action will create air spaces (usually 1-2% air). The admixture that is added to create an even void structure throughout the mix concrete containing should not be overworked. Over finishing air entrained concrete can work the air out of the concrete surface reducing the positive effects of air entrainment.

Voids are the area between the solid particles. Voids make up over 65% of the volume of the concrete.

Specific Gravity is the ratio of items mass to an equal volume of water.

Unit Weight is the mass of an item for a given volume (example concrete = 145.3 lbs/ft^3).

Strength is the compressive resistance of the concrete in pounds per square inch after 28 days of cure time (the sample load divided by the sample square area).

Cubic Yard the most widely used term when ordering concrete. A cubic yard will fill a form 3ft x 3ft x 3ft (concrete is sold by volume but produced by weight).

DEICING CHEMICALS

There are four main types of deicing chemicals used throughout the US today:

- Sodium Chloride is the most widely used. It is also referred to a rock salt. It will keep ice and snow melting until the temperature is around 15°F. This type is also very high in chloride ions which lead to early rebar corrosion.
- Calcium Chloride will continue to melt snow and ice until the temperature is around 0°F. It will also lead to chemical attack on the concrete.
- Potassium Chloride is not used as much as others but can still are found. It will not work unless the temperature is above 18°F.
- Magnesium Chloride is used at airports and will work when the temperature is as low as -10°F. This chemical melts snow and ice very quickly.

Each year new products come out with a label 'safe for concrete.' Read this label carefully! If it contains any of the above products and/or sodium, use with extreme caution. Avoid products with ammonium nitrite or sulfate. Some fertilizing products can also be used, however, these can be damaging to the surface of the concrete. If traction is needed on the roadway, use sand instead.

What do deicing chemicals do? And are they harmful to concrete?

- Deicing chemicals lower the freezing point of water. Liquid that normally freezes at 32°F might now not become a solid until the temperature is between 18 and 25°F. This allows the water, in the liquid form, to enter the concrete's surface and then re-freeze much quicker. As the evening comes some other chemicals, such as magnesium chloride, will continue to work in temperatures below 0°F.

- Deicing chemicals can attack reinforcement in the concrete and lead to corrosion of the rebar or steel.

- Many times during cold weather with ice and snow, the surface of the concrete may not drain properly. When the temperatures get above freezing, ice or snow buildups on flat surfaces and act like a dam. This allows the water containing the chemicals to sit on the concrete too long.

- Most deicing chemicals are overly applied so they do not perform as they are designed to. In addition, they lay on the surface and attack the concrete surface.

- Salts are, by nature, a corrosive material that can alter the PH level of the concrete at the surface. The salt can interact with the concrete in a chemical reaction as well. These are in the form of carbonation. The penetration of chloride ions and ettringite formation will affect the concrete's ability to withstand freeze-thaw cycles even when the concrete has the proper air entrainment. Any cracks or control joints will allow the reaction to reach deeper into the concrete. Thus the permeability (concrete's ability to repel and withstand such conditions) will be compromised. (larger pavement and concrete slabs that are exposed to both weather and heavy traffic flow should consider joint sealing and a program that maintains said sealing of construction joints)

- Deicing chemicals aggravate and speed up scaling. They reduce the resistance abilities of the concrete with air entrainment admixtures to withstand the effects of freeze-thaw cycles.

- When combined with water from the snow and melting ice, deicing salts slowly make their way into the concrete matrix through cracks or control and construction joints. Once in the concrete, they can attack both the concrete and reinforcing steel.

- While deicing salts do their job on sunny days, many times after the day begins to end the water will refreeze on the concrete. This makes for slick spots and aids in repeated freeze-thaw cycles.

What can be done to stop these problems?

Vigilant planning and better mix designs help alleviate some of these problems. Careful placement in cold weather conditions is also important. Proper curing should always be done but especially if bad weather is fast approaching.

Consider an upgrade in the choice of coarse aggregates with better grading. Avoid marginal aggregates since some are reactive and can lead to ASR issues. Aggregates should be frost-resistant. Be sure aggregates can pass:
- ASTM C 1293
- ASTM C 1260
- ASTM C 1105

Adequate air void systems and proper air content is very important for good concrete. Using proper amounts of air entrainment gives the proper spacing factor according to ASTM C 457.

Proper placement is essential and curing by contractor's placement should always be on a well-drained compacted subgrade. The concrete should be placed as close as possible to its final finishing position (dragging concrete a long ways will result in the aggregate being separated from the paste and create large voids).

Be sure the concrete is properly cured by the concrete contractor. Concrete should always be cured unless pre-arrangements are made and all parties involved have agreed. Several curing methods will work:

- wet cure
- plastic or burlap
- hay or straw

The most widely used curing method today are liquid membrane curing compounds that may be sprayed or rolled on after the concrete is finished and no damage will be done to the surface. They come in both water-based and solvent or lacquer types. ASTM has specifications for both:

- ASTM C 309 is curing only!!!!
- ASTM C 1315 curing with special properties (can later be used as a sealer)

ASTM C 156 covers moisture loss issues with concrete. Coverage rates on these compounds will vary according to concrete surface and the type. Carefully read directions before application of cures. The importance of curing cannot be overstated. Concrete is sold on demand and weather does not care that the concrete needs low humidity and low winds. It is very important to keep hydration water in the mix as long as possible to help with these environmental issues.

Experienced contractors should apply sealers. Even coverage is a must when using sprayers. It is recommended that a spray and back-roll method be used achieve the best results. Two coats will need to be applied. Apply 2/3 of the sealer then back-roll 1/3 from a different angle. Nozzle spraying should move into the previously applied area about 25% to insure a complete coverage. When sealers are applied on textured surfaces, such as stamped concrete, avoid over application that will runoff into the lower areas.
Both nozzle opening size as well a wand length will also play a great role in proper coverage/

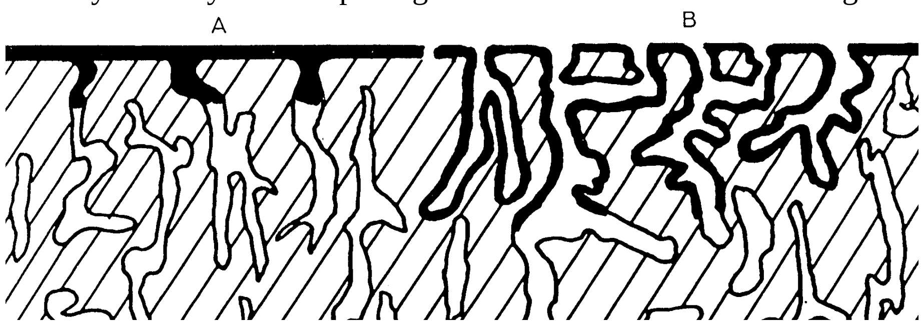
A sealed concrete surface will not allow water or damaging salts to enter the concrete. Sealers also make the concrete much easier for snow and ice removal.

There are several types of sealers to choose from based on what application the concrete is being used for:

- Water based
- Solvent or lacquer based (ASTM C 1315 classifies many of these as a cure and seal, meaning they can do two things at different stages in the concretes age)
- Penetrating sealers, such as silane or siloxane

Both water based and solvent sealers react with the concrete in a physical reaction forming a membrane on the concrete surface. They will darken the appearance of the concrete much like it looks when it's wet. Depending on use and wear, these can last from 6 months to 5 years. Always check with the manufacturer for both coverage and expected wear time. Also note that weather conditions play a part in application. Avoid water based sealers when freezing temperatures are expected within 48 hours of application. These offer excellent protection from not only salt damage but from oil, gas spills and fertilizer damage.

Penetrating sealers seal by lining the pours and capillaries in the concrete making them hydrophobic in nature. These types of sealers both are able to repeal water and are able to breathe. They not only aid in repelling water but also aid in eliminating moisture that can also lead to rebar corrosion.



The figures below show how sealers work and repel water. Figure A is a normal cure and seal product whereas figure B is a siloxane sealer:

Use of concrete sealers can add to life/cycle of concrete, and avoid costly replacement, use of the above penetrating sealers make the concrete truly 100% breathable.
Concrete as a building material is a great value but care must be taken to insure it properly cures and will be able to withstand harsh conditions it might be exposed to.

One of concrete main functions will be to carry loads imposed and withstand conditions it will be exposed too.
Concrete finishers, general contractors, ready mix and curing suppliers as well as owners should all understand the importance of not only placement, and cure methods but hydration of concrete.

Over the past decades we have made advances in how cars are built to avoid rust; how paint is made to withstand weather conditions, we must also look at concrete in much the same way protection will only add a few cents to life cycle costs but increase the life span by years.