Tech Spec Guide

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Tech Spec 5

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Cleaning, Sealing and Joint Sand Stabilization of Interlocking Concrete Pavement

When properly installed, interlocking concrete pavements have very low maintenance and provide an attractive surface for decades. Under foot and vehicular traffic, they can become exposed to dirt, stains and wear. This is common to all pavements. This technical bulletin addresses various steps to ensure the durability of interlocking concrete pavements and to help restore their original appearance. These steps include removing stains and cleaning, plus joint stabilization or sealing if required.

Stains on specific areas should be removed first. A cleaner should be used next to remove any efflorescence and dirt from the entire pavement. A newly cleaned pavement can be an opportune time to apply joint sand stabilizers or seal it. In order to achieve maximum results, use stain removers, cleaners, joint sand stabilizers, and sealers specifically for concrete pavers. These may be purchased from a manufacturer, contractor, dealer or associate member of the Interlocking Concrete Pavement Institute.

Removing Stains

Commercial stain removers available specifically for concrete pavers provide a high degree of certainty in removing stains. Many kinds of stains can be removed while minimizing the risk of discoloring or damaging the pavers. The container label often provides a list of stains that can be removed. If there are questions, the supplier should be contacted for help with determining the effectiveness of the chemical in removing specific stains.

Figure 1. Many sealers enhance the appearance of concrete pavers and protect against staining.

Identify the stains prior to applying the cleaner. A test application should be evaluated in a small, inconspicuous stained area for cleaning effectiveness. Some stains may require repeated applications of the remover to achieve effective cleaning. This is often the case for deep set oil stains. With all stain removers, cleaners, joint sand stabilizers, and sealers, the label directions and warnings should be read and carefully followed for all precautions.

Start removal of stains at the bottom of the pavement and work up the slope in manageable sections. By working up the slope, cleaning fluids will drain down the pavement. This technique assists in uniform removal while allowing the used cleaner to be rinsed away consistently. The surface remains dry ahead of the cleaner-soaked wet areas, allowing better visibility of the stains to be removed.

Take care in selecting and applying cleaning products, as acidic ones may harm vegetation and grass. These cleaners should not run onto vegetation. When using strong acidic stain removers or cleaners that might drain onto vegetation, saturate the vegetation with water prior to using acidic cleaners. This will minimize absorption of cleaner rinse water and reduce risk of damage to vegetation.

Removal of Common Stains

There are proprietary cleaning products specifically designed for concrete pavers. Many have been developed through extensive laboratory and field testing to ensure cleaning effectiveness. These chemicals should be used whenever possible. Using manufactured cleaning chemicals for specific stains relieves the user from the uncertainty of attaining the proper mixture of chemicals.

If no proprietary stain removal products are available, a comprehensive source of information on stain removal is found in *Removing Stains from Concrete* by William H. Kuenning. It describes chemicals, detergents or poultice (scrubbing) materials recommended for removing particular stains, and the steps to be followed in removal. This publication recognizes that some of the treatments involve hazardous chemicals and it advises specific precautions.

Removal of several common stains from *Removing Stains from Concrete* are listed below (1). Most involve typical house-

hold chemicals. Searching the internet using the key phrases mentioned below can provide additional information. The ICPI disclaims any and all responsibility for the application of the information. The user is advised to use cleaners specifically made to remove stains that commonly occur on concrete pavers. They will likely be more effective.

Asphalt and emulsified asphalt—Chill with ice (if warm outside), scrape away and scrub the surface with scouring or abrasive powder. Rinse thoroughly with water.

Cutback asphalt and roofing tar—Use a poultice made with talc or diatomaceous earth. Mix with kerosene, scrub, let dry and brush off. Repeat as needed.

Blood, candy, ketchup, mustard, grease drippings from food—For stubborn stains, apply liquid detergent full strength and allow it to penetrate for 20 to 30 minutes. Scrub and rinse with hot water. Removal is easier if these stains are treated immediately.

Caulking—Scrape off excess and scrub with a poultice of denatured alcohol. Rinse with hot water and detergent. Acrylic latex caulk—follow guidelines for removal of latex paint.

Chewing gum—Same as caulking, or scrub with naphtha.

Clay soil—Scrape off dry material, scrub and rinse with hot water and strong detergent.

Creosote—Apply a poultice with paint thinner and talc. Scrub and allow to dry. Scrape off, scrub with scouring powder and rinse with water.

Leaf, wood rot, or tobacco stains—apply household bleach and scrub with a stiff bristled brush.

Mortar—Let harden and carefully remove hardened spots with a trowel, putty knife or chisel.

Smoke—Scrub with a poultice of talc with bleach diluted 1:5 with water. Rinse with water.

Oil or grease that has penetrated—Mop up any excess oil with rags. Cover the area with oil absorbent (kitty litter). Talc, fuller's earth, diatomaceous earth can be used. Leave it on the stain for a day then sweep up.

Paint—Fresh paint should be mopped up immediately with rags or paper towels by blotting. Do not wipe as this will spread the paint and extend the job of removal. If the paint is latex and water based, soak and then scrub the area with hot water, scouring powder and a stiff brush until no more improvement is seen. Let the remaining paint dry and remove as described below.

Dried paint—Scrape any excess oil based paint, varnish or water based latex paint off the surface. Apply a commercial paint remover and let it sit for 20 to 30 minutes. Loosen with gentle scrubbing. Do not rub the loosened paint into the surface of the paver. Instead, blot up the loosened paint and thinner. Repeat as necessary.

Tire skid marks—Scrub black area with water, detergent and scouring powder.

In the case of small stained areas, removal and replacement with new pavers may be an option.

Overall Cleaning

Overall cleaning of the pavement can start after stains are removed. In preparation for cleaning, low tree branches, shrubs and vegetation adjacent to the pavement should be tied back or covered to protect from overspray of cleaning solutions or sealers. The area should be inspected for any cracked or broken units. These should be replaced. Badly stained units can be replaced, but it is usually easier to clean stains and less costly than replacing the pavers.

When pavers have stains too difficult to remove, replace them with the same type of units. Refer to *ICPI Tech Spec 6, Reinstatement of Interlocking Concrete Pavements*, for a full description on replacing pavers. If pavers must be replaced, there may be a difference in color from the surrounding pavers. This variation should eventually disappear. If color variation is unacceptable, controlled use of proprietary cleaners designed to improve the color of concrete pavers can minimize variation.

Removal of accumulated dirt and efflorescence is the objective of cleaning. It is essential in preparing the pavers for sealing as well. Many cleaners effective in removing dirt and efflorescence are a mix of detergent and acid. Cleaners with strong acids will change the color of the pavers slightly. The degree of change can be controlled by the type of acid in the cleaner, its concentration and the length of time on the pavers. Proprietary cleaners will give specific instructions on their application. These directions should be followed. In order to achieve proper results, cleaners should be tried on a small area to test results and any color changes. The concentration and time on the pavement can be adjusted accordingly. Protective clothing and goggles should always be worn when using acidic solutions.

Anticipate where the cleaning fluids will drain, i.e, across the pavement and not onto grass or vegetation. Sediment or cleaners allowed to pond in low spots may stain the pavers. If unsure of the runoff direction, test drainage with ordinary water first to identify any trouble spots. Be sure to rinse these areas thoroughly. Turn off all automatic sprinkler systems during cleaning, sealing and drying.

Professional Cleaning Methods

For most jobs, cleaning should be handled by a professional company experienced in the use of cleaners and spray equipment. Professionals typically use a pressure washer and an applicator to apply efflorescence cleaner (when needed). The various methods for applying joint sand stabilizers and sealers are covered later.

A high pressure sprayer applies cleaner and water between 1,000 and 4,000 psi (6.9 and 27.6 MPa), and at a rate between 2 and 6 gallons/minute (7.6 and 22.7 liters/minute). See Figure 2. The rate of flow is adjusted to ensure sufficient rinsing. The pressure loosens dirt and pushes water from the surface without the need for scrub brushes. The nozzle type and its distance from the paver surface influences the effectiveness of the cleaning as well. A nozzle that creates a wide spray enables a large area to be covered efficiently and prevents sand from being washed from the joints. A low angle of attack from a wide nozzle spray will also reduce the risk of dislodging joint sand.

Cleaners to remove efflorescence are applied with a low pressure pump spray 30 to 100 psi (0.2 to 0.7 MPa). A shower type spray nozzle will help ensure even distribution of the cleaner. Cleaning

chemicals are applied, allowed to sit an appropriate time, then rinsed away with a high pressure sprayer. The final rinse should be water only. A large amount of water is more important to rinsing than high pressure.

For small areas, an adequate cleaning job can be achieved without this equipment. Such areas include residential patios, walks, or small driveways. Cleaners can be applied by hand, the pavers scrubbed to remove dirt and efflorescence, then thoroughly rinsed with water from a garden hose. Scrub brushes with steel bristles are not recommended. They will loosen from the brush, rust, and leave stains. Brass or plastic bristles are acceptable. This method of cleaning is for do-it-yourselfers who wish to refurbish a small area of pavers.

The additional time required to clean and seal pavers without the help of a professional should be weighed against investing in a competent company to do the job. Professionals have the equipment and experience with the various chemicals. They can achieve the highest level of results in the least amount of time.

Efflorescence and Its Removal

Efflorescence is a whitish powder-like deposit which can appear on concrete products. When cement hydrates (hardens after adding water), a significant amount of calcium hydroxide is formed. The calcium hydroxide is soluble in water and migrates by capillary action to the surface of the concrete. A reaction occurs between the calcium hydroxide and carbon dioxide (from the air) to form calcium carbonate, then called efflorescence.

Efflorescence does not affect the structural performance or durability of concrete pavers. The reaction that takes place is the formation of water soluble calcium bicarbonate from calcium carbonate, carbon dioxide and water. It may appear immediately or within months following installation. Efflorescence may reach its peak in as short as 60 days after installation. It may remain for months and some of it may wear away. If installation takes place during dry period of the year, the next cycle of wet weather may sometimes be necessary for efflorescence to materialize.

If there is a need to remove deposits before they wear away, best results can be obtained by using a proprietary efflorescence remover. The acid in proprietary cleaning chemicals is buffered and blended with other chemicals to provide effective cleaning without damage to the paver surface. Always refer to the paver supplier or chemical company supplying the chemicals for recommendations on proper dilution and application of chemicals for removal of efflorescence. They are generally applied in sections beginning at the top of slope of the pavement. If the area is large, a sprayer is an efficient means to apply the cleaner. The chemicals are scrubbed on the surface, then rinsed away. Results can be verified after letting the area dry for at least 24 hours. In most instances one application is sufficient. However, in severe instances of efflorescence, a second application may be necessary. Contact the manufacturer of the cleaning product to determine if a second application will not discolor the pavers or expose some aggregates. Note: Protective clothing, chemical resistant rubber boots and gloves, and eye goggles should be worn when applying acid or alkalies.

Figure 2. Pressurized cleaning equipment used by professional cleaning and sealing companies can bring out the best appearance from pavers.

Joint Sand Stabilizers And Sealers

Stabilizer and sealers are two distinct products sometimes with overlapping functions. Joint sand stabilizers help secure sand in the joint after it has been installed. Their primary function reduces the risk of removal of joint sand from flowing water, wind, aggressive cleaning, tire action and intrusion of organic matter, seeds and insects.

Joint sand stabilizers come in liquid and dry applied forms. Some liquid stabilizers are made of the same materials as sealers, but with a higher solids content with additional wetting agents. When applied to the paver surface and joints, stabilizers can make the surface easier to clean and prevent staining in a manner similar to sealers. Depending on the chemical contents, liquid stabilizers may or may not change the appearance of the paver surface.

All surface sealers are applied as liquids. Their primary function is providing additional protection to concrete paver surfaces. Such chemicals can be similar to products used to seal cast-in-place concrete slabs. Sealers are applied to the entire surface of an installation to add further protection from stains, oils, dirt, or water. Occasionally, sealers are applied to pavers during manufacturing. Whether applied in a factory or on a site, most sealers change the appearance of the paver surface by darkening it and enhancing the surface color. Since liquid sealers penetrate the joint sand to some extent during application, they secondarily provide some stabilization.

Joint Sand Stabilizers

Liquid and dry applied stabilizers provide initial protection against joint sand loss. They accelerate joint sealing that can normally occur from a combination of atmospheric dust deposits, dirt and sediment that finds its way to the pavement, and contributions from passing tires. Stain removal, efflorescence removal, and overall surface cleaning should precede application of liquid stabilizers in new construction. None of these preparatory treatments are needed prior to the application of a dry applied stabilizer. It is applied first with the joint sand to complete the paver surface and begin interlock. Stain and efflorescence removal, cleaning and sealing can be done subsequently.

Given the wide range of joint sand stabilizers and proprietary formulations, it is best to consult with the manufacture to determine expected lifespan and/or reapplication rates.

Joint sand stabilization is generally optional and not required for many interlocking concrete pavements. Sand in joints will likely stabilize over time without additional treatment as a result of silts or other fines working their way into spaces between the

Figure 3. This liquid joint sand stabilizer is applied with a low-pressure sprayer and squeegeed across the surface after allowing some time for soaking into the joints. This helps maintain slip and skid resistance of the paver surface.

Figure 4. Liquid joint sand stabilizers can deepen the surface color slightly and they provide some surface sealing as well. Tumbled pavers shown here have wider joints than other shapes. These type of pavers can require stabilization of the joint sand.

Figure 5. Joint sand can be pre-mixed and delivered to the site (typically in bags), or mixed with stabilizer at the site, then swept into the joints, compacted for consolidation in them to create interlock, and wetted to activate the stabilizer.

sand particles. The rate of stabilization depends on the amount and sources of traffic, plus sources of fines that work their way into the joints from traffic over time.

There are some applications where early stabilization of the joints is important to maintaining functional performance of the paver surface. For example, stabilization is recommended on high slope applications over 7% and on applications where the slope is less than 1.5%. Applications on high slopes will help prevent washout of joint sand. Stabilizers in very low slope or flat areas can help reduce infiltration of standing water.

Stabilization benefits pavements subject to aggressive, regular cleaning. Examples might include amusement parks and restaurant exteriors. Pavements that see regular, heavy rainfall can benefit from stabilization of the joint sand. Surfaces that experience concentrated water flow such as gutters receiving sheet flow from large areas or at the drip lines under the eaves of buildings will better resist erosion of joint sand if stabilized.

Stabilizers have been effective in securing joint sand in places subject to high winds such as in desert climates. They can prevent joint sand displacement from high-speed tire traffic. Like sealers, joint and stabilization materials reduce the potential for weeds and insects in the joints. In residential applications stabilization at downspouts and under eaves helps keep joint sand in place. Tumbled pavers (cobble stone-like units) and circular patterns have wider joints than other paver shapes. Tumbled pavers may require stabilized joint sand between them if they have slightly irregular sides and wide joints.

Studies on the permeability of the surface of interlocking concrete pavements have indicated ranges between 10% and 20% perviousness (2). The rate of permeability depends on several factors. They include the fineness of the joint sand (percent of material passing the No. 200 or 0.075 mm sieve), the joint widths, slope, consolidation of the sand plus the age of the installation. Newly placed pavers have higher permeability (as much as 25%) than installations trafficked for several years. Sealers and joint sand stabilizers can contribute to long-term performance by reducing infiltration of water to the bedding sand and base.

Figure 6. Whether using liquid or dry joint stabilization materials, the surface of the pavers should be cleaned with a blower or broom after the joint sand is compacted into the joints.

Figure 7. Dry-applied joint sand with a stabilizer is wetted in order to activate it and stiffen the sand. Once the joints dry, they are stabilized.

Liquid Penetrating Stabilizers

These are water or solvent-based with the primary resin or bonding agent being an acrylic, epoxy, modified acrylic, or other polymers as solids (by volume) typically 18% to 28%. Solvent or water carries the solids into the joint sand. They will evaporate and leave the solids behind as the binding agent. Modifiers such as epoxy resins may also add to the ability of the product to create a solid matrix in the joint sand. When initially applied, liquid stabilization materials should be allowed to penetrate at least 3/4 inch (20 mm) into the joint sand. A mock-up is beneficial in determining application rates for specific products, joint sands, and for specific job site conditions.

Joint sand gradation can affect the depth of penetration of the liquid stabilizer. The amount of fines or material passing the No. 200 (0.075 mm sieve) can influence the depth of penetration. A joint sand gradation with less than 5% passing the No. 200 (0.075 mm) sieve can allow better penetration of liquid stabilizers. A job site mock-up should be tried to determine the penetration rate. The mock-up also will determine the appropriate application rate.

Prior to applying liquid materials, the surface should be clean and dry and any efflorescence removed from the pavers. Either a broom or leaf blower can efficiently remove excess sand. Some successful methods of application involve applying liquid

joint stabilizers with low pressure, high volume spray, followed immediately by a squeegee to move the material into the joints. See Figure 3. Other methods use rollers, watering cans, or hand pumped, garden-type sprayers. Some equipment has multiple spray nozzles and mechanized rollers and/or squeegees. All application methods must provide uniform dispersion and effective penetration.

Liquid stabilizers bind the sand in the joint and secondarily provide sealing of the concrete paver surface. All liquid based stabilizers create some change in the appearance of the pavers. This ranges from a slight color enhancement, a modest sheen, to a high gloss. Like sealers, cured liquid stabilizers that remain on the surface of the pavers enhance their color, inhibit fading, and protect against staining. It also makes the paver surface easier to clean and maintain (Figure 4). However, joint sand stabilization will last significantly longer than the enhancement of the surface appearance.

Dry Joint Sand Stabilizers

These are dry additives mixed with joint sand. The additives are organic, inorganic, or polymer compounds that stiffen and stabilize the joints when activated by water applied to the joint sand. Additives come either pre-mixed with bagged joint sand, or are sold separately as an additive mixed with the joint sand on the job site per the supplier's instructions. The additive is often mechanically mixed for consistency. Dry stabilizers are appropriate for residential settings, parking lots, bike lanes, plazas, and other areas with low velocity wheel loads or areas without concentrated water flow. They are convenient for application by homeowners. Some dry stabilizers have been successfully used in high traffic streets.

The pavers are initially compacted into the bedding sand. Joint sand is applied to the surface with a stabilizer additive mixed in it. See Figure 5. It is then compacted into the joints with a plate compactor like all interlocking concrete pavement installations. After compaction and removal of all sand from the paver surface, the joints are wetted. When dry, the material in the sand stabilizes the full depth of the joint and it helps maintain interlock among the pavers. For either pre-mixed or job site mixed additives, a job site mock-up is beneficial for determining the depth of stabilization. The mock-up will determine the rate and application method of water to ensure full activation of the stabilizer. A mock-up will confirm a consistent method for uniform distribution of the additive in the sand for job site mixed additives in particular.

Prior to application, blowing or sweeping the surface clean is recommended. Use of a respirator and restricting access to the area must be addressed to comply with OSHA regulations. See Figure 6. Since water activates these products, no moisture should be present on the surface or in the joints until they are ready to be placed in the joints. Once the pavers and joint sand are compacted, the joints are full of sand, and all excess sand is removed from the surface, water is added to activate the bonding agent. The water is applied as a light, wide spray, and allowed to collect and soak into the joints (Figure 7). A narrow spray should not be used because it can dislodge sand from the joints. It is imperative to immediately remove any excess moist joint sand that inadvertently gets on the surface of the pavers. Otherwise, once it is moistened and allowed to cure on the surface, the sand will need to be removed with hot water. Some stabilizers may require removal with a wire brush or a pressure washer. Dry products will not leave a surface sheen like liquid stabilization products. This can be beneficial for a contractor or owner who needs to stabilize isolated areas through selected application of the product.

Installation, Functional and Structural Considerations

Liquid and dry applied joint stabilizers are not a substitute for recommended installation practices. Prior to their application, all liquid stabilization products require that the joint sand be compacted and consolidated in the joints until full. Some dry stabilizers require mixing with joint sand then spreading, filling, and compacting the sand and pavers until the joints are full. Other stabilizers are premixed in bags and are ready for filling the joints. Stabilizers resist many of environmental conditions that lead to functional deterioration of the paver surface. However, stabilizers do not add to the structural (load bearing) capacity of the pavement. Therefore, structural calculations for base thickness design should not consider a joint sand stabilizer.

Sealers

Uses

Sealers reduce the intrusion of water, stains, oils and dirt into the paver surfaces. Like stabilizers, application of a sealer follows stain removal, efflorescence removal and overall surface cleaning. Sealers are used for visual and functional reasons. They offer visual

Figure 8. Before and after application of an acrylic sealer shows how it deepens the appearance of concrete pavers.

Photo courtesy of Resiblock

Figure 9. Sealers resist stains which makes them ideal for high use areas where they might occur.

improvement by intensifying the paver colors. Some will add a glossy sheen or "wet" look to the pavement (see Figure 8). Other sealers offer some color enhancement and produce a low sheen, or a flat finish.

Sealers offer many functional advantages. They can protect pavers from stain penetration. They are useful around trash receptacles, fast food restaurants, driveways, other areas subject to stains, and where oil drippings are not wanted (see Figure 9).

Like stabilizers, sealers are also useful in stopping unwanted insects and weeds. Sealers can stabilize joint sand between pavers cleaned by vacuum equipment. They can help maintain the sand in the joints under high velocity water flows. Where solvents may be spilled onto pavers, elastomeric urethanes and certain water based sealers have been successfully used to prevent their penetration. Likewise, special urethane sealers have been used to seal and stabilize joint sand subject to propeller wash, jet engine fuels and exhaust in commercial and military airports (2).

Types of Sealers for Concrete Pavers

Table 1 lists the various types of sealer for concrete pavers. The table suggests applications and compares important properties (3). The sealer manufacturer or supplier should be consulted prior to using any sealer to verify that their product will perform in the environment planned for its use. Sealers not recommended for use with pavers are alkyds, esters, and polyvinyl acetates. Epoxies and silicones are generally not used on concrete pavers.

Solvent and Water Based Sealers

Like stabilizers, sealers can be either solvent or water based. Solvent based sealers consist of solids dissolved in a liquid. Solvent based products carry the dissolved solids as deep as the solvent will penetrate into the concrete paver. After the solvent evaporates, the sealer remains.

Water based sealers are emulsions, or very small particles of the sealer dispersed in water. Water based sealers penetrate concrete as far as the size of the particles will permit. After the water evaporates, typically at a slower rate than solvents, the remaining particles bond with the concrete and to each other. These particles cannot penetrate as deeply as those carried by solvents. Water based sealer curing time will vary with the temperature, wind conditions and humidity.

Silanes/Siloxanes

Silanes and siloxanes penetrate concrete well. Silanes are the simpler form that, when exposed to moisture, begin to link up to other silanes. Siloxanes do the same linking together. Both chemicals become a polymer, curing as a film in the capillaries of the concrete. A hydrophobic barrier to moisture is created, preventing moisture from entering but allowing the concrete to "breathe" or release water vapor.

Because silanes and siloxanes reduce moisture from entering the concrete, they can deter efflorescence from appearing on the surface of concrete pavers. They initially enhance colors and produce a flat, no-gloss finish on the paver surface. This makes silanes and siloxanes very suitable on exterior areas for resisting efflorescence when a glossy surface is not desired.

Silanes and siloxanes do not resist penetration of petroleum stains unless they have additives specifically for that purpose. When required, proprietary mixtures with additives can increase petroleum stain resistance. Other additives can ensure greater consistency in the color of pavers and avoid a blotchy appearance.

Silanes have smaller molecules, so they penetrate farther into the concrete than larger siloxane molecules. However, they are more volatile (tend to evaporate) until they bond to the concrete paver. Silane sealers generally require a higher percent of solids to counteract their rate of evaporation. Therefore, silanes tend to be more expensive than siloxanes.

Silanes and siloxanes are typically used as water repellents for concrete bridge decks, parking garages, and masonry walls. Their primary use for reinforced concrete structures is to prevent the ingress of chloride ions from deicing salts (4). This intrusion causes reinforcing steel corrosion in the concrete, and a weakened structure. Their ability to decrease intrusion of chloride materials provides additional protection of pavers subject to deicing salts or salt air, such as walks, streets, parking lots, plaza roof and parking decks. They are also useful around pool decks to minimize degradation from chlorine.

Most silane and siloxane sealers are solvent based. Certain manufacturers offer water based products as well. These products may have a very short shelf life after the silane or siloxane has been diluted with water. The user should check with the manufacturer on the useful life of the product.

Acrylics

Acrylic sealers can be solvent or water based. They enhance paver colors well and create a gloss on the surface. Acrylic sealers provide good stain resistance. Their durability depends on traffic, the quality of the acrylic and the percentage of solids content. They provide longer protection from surface wear than silanes or siloxanes.

Acrylic sealants are widely used in residential and commercial paver applications. They generally last for a few years in these applications before re-coating is required. Acrylics specifically developed for concrete pavers do not yellow over time. When they become soiled or worn, pavers with acrylics can be easily cleaned and resealed without the use of extremely hazardous materials.

Acrylics should not be used on high abrasion areas such as industrial pavements or floors. Water based acrylics perform well for interior applications. They may be allowed by municipalities that regulate the release of volatile organic contents (VOCs) in the atmosphere.

Urethanes

As either solvent or water based, polyurethanes produce a high gloss and enhance the color of pavers. Aromatic urethanes should contain an ultra-violet (UV) inhibitor to reduce yellowing over time. The product label should state that the sealer is UV stable. Urethanes themselves are more resistant to chemicals than acrylics.

While aliphatic urethanes can be used for coating the surface of pavers, elastomeric (aromatic or aliphatic) urethanes should be

used where the primary need is to stabilize joint sand. For airfield and gas station applications, the urethane should have a minimum elongation of 100% per ASTM D 2370, *Standard Test Method for Tensile Properties of Organic Coatings*. Urethanes resist degradation from petroleum based products and de-icing chemicals. This makes them suitable for heavy industrial areas, as well as airfield and gas station pavements.

Table 1—Properties of Sealers for Concrete Pavers—Confirm application and properties with supplier.

	Patios, walks, pool decks	Residential/ Comlercial drives	Gas Stations Airports	Areas subject to chlorine & heavy de-icing salts	Finish	Enhances color	Joint sand stabilizer	UV resistant	Can be re-coated	Ease of removal	Price
Silane	Yes	Yes		Yes	Flat	*		Yes	Yes	Mod.	++
Siloxane	Yes	Yes		Yes	Flat	*		Yes	Yes	Diff.	++
Acrylic	Yes	Yes			Gloss	Yes	Yes	Varies	Yes	Diff.	+
Urethane	Yes	Yes	Yes	Yes	Gloss	Yes	Yes	Varies	No	V. Diff.	++
Water-based Epoxy	Yes	Yes	Yes	Yes	Semi-Gloss	Yes	Yes	Yes	Yes	Mod.	++

*Initially, then diminishes. Diff.=Difficult V. Diff.=Very Difficult +=Moderate Price ++=Higher price

Urethanes cannot be rejuvenated simply by re-coating. If urethane sealers must be removed, methylene chloride or sand blasting is often necessary. Methylene chloride is a hazardous chemical, and is not acceptable for flushing into storm drains. It should not be allowed to soak into the soil. Therefore, urethane removal is best handled by professionals.

Water Based Epoxy Sealers

Water based epoxy sealers combine other types of sealers with epoxy. They cure by chemical reaction as well as by evaporation. They have very fine solids allowing them to penetrate deep into concrete while still leaving a slight sheen to enhance the color of the pavers. They generally do not change the skid resistance of the surface. When applied, water based epoxy sealers create an open surface matrix that allows the paver surface to breathe thereby reducing the risk of trapping efflorescence under the sealer should it rise to the surface. They resist most chemicals and degradation from UV radiation. These characteristics make these types of sealers suitable for high use areas such as theme parks and shopping malls. The elasticity and adhesion of these sealers make them appropriate for heavily trafficked street projects and areas subject to aggressive cleaning practices.

Sealing Procedures

All dirt, oil stains and efflorescence must be removed prior to sealing. The cleaned surface must be completely dry prior to applying most sealers. Allow at least 24 hours without moisture or surface dampness before application. The pavers may draw efflorescence to the surface, or the sealer or liquid stabilizer may whiten under any one of these conditions:

- The surface and joints are not dry
- The pavers have not had an adequate period of exposure to moisture
- There is a source of efflorescence under the pavers (i.e, in the sand, base, or soil) moving through the joint sand and/or pavers
- The sealer is not breathable, i.e., does not allow moisture to move through to the surface of the paver and evaporate.

If the base under the pavers drains poorly, the sealer is applied to saturated sand in the joints, or is applied too thick, the sealer can become cloudy and diminish the appearance of the pavers. In this situation, the sealer must be removed or re-dissolved. Consult your sealer supplier for advice on treating this situation.

Cover and protect all surfaces and vegetation around the area to be sealed. For exterior (low-pressure) sprayed applications, the wind should be calm so that it does not cause an uneven application, or blow the sealer onto other surfaces. For many sealers, especially those with high VOC's, wear protective clothing and mask recommended by the sealer manufacturer to protect the lungs and eyes.

Sealers can be applied with a hand roller if the area is small (under 1000 ft^2 or 100 m^2). For larger areas, more efficient application methods include a powered roller, or a low pressure sprayer. Sealers are often applied with a foam roller to dry pavers having clean surfaces and chamfers. However, the use of a squeegee to spread the sealer will avoid pulling joint sand out of the joints. See Figure 10.

Sealer should be spread and allowed to stand in the chamfers, soaking into the joints. Penetration into the joint sand should be at least 3/4 inch (20 mm). The excess sealer on the surface is pushed to an unsealed area with a rubber squeegee. The action of a squeegee wipes most of the sealer from the surface of the pavers while leaving some remaining in the chamfers to eventually soak into the joints. Generally only one coat is required.

Figure 10. Urethane is applied with squeegees to stabilize joint sand between pavers on aircraft pavement.

For other applications, follow the sealer manufacturer's recommenda-

tion for application and for the protective gear to be worn during the job. With some sealers that recommend two coats, the first coat is usually applied to saturation. A light second coat, if needed, can be applied for a glossy finish. Be careful not to over apply the sealers such that the surface becomes slippery when cured. For water based sealers requiring two coats, always apply the second coat while the first coat is still very tacky. Prevent all traffic from entering the area until the sealer is completely dry, typically 24 hours.

If spraying sealer on the pavers, care should be taken to prevent the spray nozzle from clogging and causing large droplets to be unevenly distributed on them. This is most important for water based sealers. This can cause a poor appearance and performance.

Sealers normally require reapplication after a period of wear and weather. The period of reapplication will depend on the use, climate, and quality of the sealer.

Safety Considerations

Adequate slip (foot) and skid (tire) resistance of concrete pavers should be maintained with properly applied joint sand stabilizer or surface sealers. See *ICPI Tech Spec 13 – Slip and Skid Resistance of Interlocking Concrete Pavements* for test methods and guidelines. See www.icpi.org to obtain this and all ICPI Tech Spec technical bulletins. The manufacturers of stabilization and sealers should be consulted concerning slip and skid resistance performance characteristics under wet and dry conditions.

Some commercial or industrial pavement use painted pavement markings. Consult with the stabilizer and sealer manufacturers for compatibility of their materials with pavement markings. Where there are pavement markings, applications using high gloss materials should be avoided as they can increase the difficulty of reading pavement markings under certain light conditions.

Federal, state/provincial, and some municipal governments regulate building materials with high volatile organic contents (VOCs). The restrictions usually apply to solvent based sealers. The VOC level of a sealer refers to the pounds per gallon (or grams per liter) of solvent which evaporates from the sealer, excluding the water. VOCs have been regulated since they can contribute to smog. Most water based sealers comply with VOC restrictions and some solvent based products may comply as well. The user should check with the sealer supplier to verify VOC compliance in those areas that have restrictions.

Many solvent based products are combustible and emit hazardous fumes. Therefore, flame and sparks should be prevented in the area to be sealed. Never use solvent based sealers in poorly ventilated or confined areas.

Persons applying joint sand stabilizers and sealers should wear breathing and eye protection as recommended by the manufacturer, as well as protective equipment mandated by local, state/provincial, or federal safety agencies. Follow all label precautions and warnings concerning handling, storage, application, disposal of unused materials, and those required by all government agencies.

The U.S. Federal Government and Canadian Government require that all shipments of hazardous materials by common carrier must be accompanied by a Material Safety Data Sheet (MSDS). All chemical manufacturers must supply sheets to shippers, distributors and dealers of cleaners, joint sand stabilizers, and sealers if the materials are hazardous. The MSDS must accompany all shipments and be available to the purchaser on request. The MSDS lists the active ingredients, compatibility and incompatibility with other materials, safety precautions and an emergency telephone number if there is a problem in shipping, handling or use. The user should refer to the MSDS for this information.

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