CrownTech™ - Technical Bulletin No. 1

Concrete Surface Preparation

CONTENT

INTRODUCTION

Crown Polymers wants each installation to be a success for the Installer, Specifier and most importantly for the Facility Owner. The information in each CrownTech™ Technical Bulletin is intended to provide accurate data to assist the Contractor in making the best informed decision.

ICRI GUIDELINE 310.2R (MODIFIED)

The construction industry has accepted ICRI Guide 310.2R to provide an adequate adhesion profile for the bonding of polymer sealers, coatings and flooring systems to properly prepared, clean, sound and durable Portland cement concrete.

Crown Polymers requires all concrete surfaces to be prepared prior to the placement of a Crown Polymer product or system.

Crown Polymers modified the ICRI Guide 310.2R Concrete Surface Profile (CSP) selection on Table 7.1, because the more aggressive surface profiling causes severe concrete micro-cracking. Severe micro-cracks can lead to premature concrete distress, which can result in loss of adhesion of the sealers, coatings and flooring systems.

Products	Thickness	CSP
Sealers	0 to 3 mils (0.0 to 0.075 mm)	1 to 2
Thin Film Coatings	4 to 10 mils (0.01 to 0.025 mm)	1 to 2
High-Build Coatings	10 to 40 mils (0.025 to 1.0 mm)	1 to 3
Self-Leveling Flooring	50 to 125 mils (1.2 to 3.0 mm)	2 to 4
Mortar Flooring	125 to 250 mils (3.0 to 6.0 mm)	2 to 4
Overlays and Sloping Mortars	250 mils and thicker (6.0 mm and thicker	2 to 4

NOTE: CROWN POLYMERS MANUFACTURES SEALERS TO TERRAZZO BINDERS AND ALL PRODUCTS IN BETWEEN. TO AVOID PREPARATION MICRO-CRACKING THE CONCRETE SURFACE PROFILING SHOULD BE LIMITED, AS NOTED ABOVE.

Surface Preparation Methods	CPS
Water Blasting	1 to 2
Acid Etching	1 to 2
Needle Scaling	2 to 4
Diamond Grinding (40 grit or larger)	2 to 4
Abrasive Blasting	2 to 4
Shot Blasting (280 to 330 shot)	2 to 4
Scarifying will cause surface micro-cracking, which will require shot blasting to remove the micro-cracked concrete.	4

NOTE: EACH OF THE SURFACE PREPARATION METHODS CAN EXCEED CROWN POLYMERS RECOMMENDED CONCRETE SURFACE PROFILE. CROWN POLYMERS RECOMMENDS LIMITS TO THE OVERLY AGGRESSIVE PROFILING.

AMERICAN CONCRETE INSTITUTE

ACI 201.1R Guide for Making a Condition Survey of Concrete in Service was developed to identify and define areas of distress. The condition survey provides guidelines that include pertinent items that have a bearing on the performance of the concrete. The guideline is not meant to replace intelligent observation or sound judgment, it is intended to enhance the understanding of the existing concrete.

Crown Polymers suggests that the Installer read and understand ACI 201.1R. The better educated the Installer is, the greater opportunity the Installer will have for a successful installation of Crown Polymers products and systems.

SURFACE PREPARATION

All concrete substrates surfaces will require surface preparation prior to the installation of polymer sealers, coatings, decks or flooring systems, including crack, spall and joint repair, resurfacing, topping, underlayment or overlayment.

The first step in these operations is extremely critical. The best materials correctly mixed and applied are doomed to fail unless the concrete substrate is properly prepared. At a minimum the concrete substrate must be prepared in compliance with minimum standards for the system to be placed per ACI, ASTM, ICRI, NACE and SSPC Standards.

Deleterious surface contaminants and deteriorated concrete must be removed, repaired if necessary and the surface roughened and cleaned. There are many different techniques, methods, and types of equipment, which can be used to effectively prepare concrete.

Shot blasters, water blasters, scarifiers, scabblers, acid etching, etc. are some of the commonly used equipment and techniques for surface preparation.

General – Concrete surfaces to be bonded must be clean and sound, which in all cases requires some form of substrate preparation.

Surface Evaluation – The following methods, tests and standards can be used to evaluate the condition of the concrete substrate and the effectiveness of the surface preparation procedure.

Strength – The direct tensile strength of the concrete substrate should be determined prior to placement of coatings and surfacing materials.

Contaminants – The presence of grease, wax, or oil may be detected by dropping a small amount of muriatic acid and a small amount of water onto the concrete prior to preparation and after preparation to determine the condition.

Contaminants Tests – There are several easy tests to determine if the concrete substrate is contaminated.

1. The surface exposed to drops of muriatic acid should react; if there is no reaction it suggests the presence of contaminants.
2. If the water droplets bead up and the water is not immediately absorbed, it suggests the presence of contaminants.

IMPORTANCE OF CONCRETE pH:

pH stands for “potential hydrogen” or “power of hydrogen” and it is measured on a negative logarithmic scale. The pH scale ranges from 0 to 14, and a pH of 7 (deionized water) is considered to be neutral.

A strong acid has a pH of 1-2, while a strong alkaline base has a pH of 13-14. A pH near 7 is considered to be neutral.

pH is a measurement of acidity or alkalinity and is defined as the negative logarithm scale of the hydrogen ion (H+) concentration. As the pH of a solution increases, the number of free hydrogen ions decreases, and a change in pH of one reflects a tenfold change in the H+ concentration. For example, there are 10 times as many hydrogen ions available at a pH of 7 than at a pH of 8 and at a pH of 9 there are 100 times (10 times 10) fewer hydrogen ions.

The industry standard is that the concrete surfaces must be sound and free of all bond-inhibiting substances, which normally have a pH below that of properly prepared concrete.

Carbonated concrete is contaminated concrete. It is not sound, durable concrete, it is weak, with especially low pull-off strengths. Therefore, it must be removed. Steel-reinforced concrete (wire-wire, rebar, dowels, etc.) is used throughout the world in the construction of bridges, marine structures, parking garages, and buildings. The alkaline environment of the concrete protects the steel from corrosion; however, this protective environment can be disrupted due to the migration of chloride ions to the steel and/or to carbonation of the concrete.

Sound and durable concrete is highly alkaline, with a pH of 10.0 or above, and it will passivate the steel. A pH below 10 indicates weak concrete, subjecting the steel to oxidation (rusting) and the concrete to internal stresses (spalling, cracking, etc.) resulting from the oxidized steel’s increase in volume. Therefore, a pH 10 or greater is recommended.

ASTM F710 - Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring:

pH Testing—Concrete floors shall be tested for pH prior to the installation of resilient flooring. Levels of pH shall not exceed the written recommendations of the resilient flooring manufacturer or the adhesive manufacturer, or both.

To test for pH at the surface of a concrete slab, use wide range pH paper, its associated pH chart, and distilled or deionized water. Place several drops of water on a clean surface of concrete, forming a puddle approximately 1 in. (25 mm) in diameter. Allow the puddle to set for 60 +/-5 seconds, then dip the pH paper into the water. Remove immediately, and compare to the chart to determine pH reading. Other pH testing methods such as pH pencils or pH meters, or both, are available and may be used to measure pH.

Readings at or above a pH of 10.0 are ideal for most epoxy primers, but may be too high for some non-epoxy adhesives. Refer to resilient flooring or decking manufacturer's written instructions for guidelines.

There is always a question of whether the surface is clean enough, as well as free of curing compounds and other bond breakers, prior to the installation of coating or flooring systems.

A simple litmus test is an inexpensive and quick way to see if the mechanical or chemical concrete preparation treatment has adequately prepared the surface. The litmus test (paper or pencil or equipment) should always be run when testing Moisture Vapor Emissions per ASTM F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Sub-floor Using Anhydrous Calcium Chloride.

CHOOSING THE RIGHT EQUIPMENT

Before starting a concrete preparation job, consider the following:

- Does the concrete have an existing coating or surfacing that needs to be removed? What is it, and what are its properties?
- What is the thickness of the concrete, overlayment, or coating?
- What is the current condition of the concrete, and what is its in place tensile pull bond strength? (ACI 503R or ASTM D7234)
- What type of material will be placed or applied?
- What is the concrete coverage thickness over reinforcement steel, if any?

Failure to consider all concrete issues per ACI 201.1R can cause result in significant mis-calculation of the required method and production rates of the surface preparation selected. The wrong material(s) could be specified for use. Environment, Health and Safety potential impact must be considered, such as volatile organic content regulations, odor threshold, dust, dirt, noise, waste-water and waste materials/packaging and disposal, suppression, etc.
After all of these concerns are addressed and answered, an educated choice regarding the type of equipment and surface preparation techniques can be made.

NEW and EXISTING CONCRETE

Concrete surfaces to be covered with polymer coatings or surfacing systems must be sound, durable and dry (in most cases) during installation and cure. The Concrete Industry Standard is that PCC be at least 28 days and Fly Ash PCC at least 56 days old before it is coated or surfaced.
The Concrete Industry Standard is not the Polymer Industry Standard. After 28 or 56 days the concrete has reached the majority of its strength and the majority of cement hydration has taken place. However, the excess water, not used in the hydration of the cement, slowly migrates out of the concrete reaching a homeostasis with its environment in around twelve months.

Concrete slabs should be placed in compliance with ACI 302.1R Guide for Concrete Floor and Slab Construction, ACI 318 Building Code Requirements for Structural Concrete and SSPC/PCSI TU-10. Concrete that is damaged or fails to comply with the conditions set forth in ACI 302.1, ACI 302.2, ACI 318, ACI 503.1-.4 and ACI 503R-Appendix A and SSPC/PCSI TU-10 and SSPC-SP 13/NACE No. 6 must be brought into compliance prior to placement of a coating or surfacing system. See reference to industry standards, ACI, ASTM, ICRI and SSPC.

WATER BLASTING

Water blasting is a method of removal of concrete surface contamination and fines from a concrete surface by impacting with an extremely high velocity stream of water. Water blasting and hydro demolition are normally used to remove significant thicknesses. This surface preparation method is usually more difficult to control than other methods of blasting and appears to produce greater surface profile irregularities. However, water blasting may be preferable if it is imperative to avoid airborne particulates, such as blasting aggregate residue, cement particles, contaminates, dust, etc. Water blasting produces a surface texture of widely varying degrees, free of contamination and fines.

Advantages:

- Dustless
- Free of vibration (does not bruise concrete)
- Relatively clean operation (except water and grit residue)
- Fast operation
- Relatively low noise operation
- Good keyed surface profile
- Removes material of the same or lesser strength

Disadvantages:

- Supply, handling and disposal of water
- Usually more costly than other methods
- Requires highly skilled operator
- High pressure water can be very dangerous
- Substrate normally is required to be dry

ETCHING-ACID (ASTM D4260)

Etching-Acid works well on horizontal non-surface-hardened and non-cure-and-seal concrete substrates. Thickened etching-acids are available for vertical surfaces. Acid etching does roughen the concrete surface, but does not remove laitance and may not loosen other materials that are acid resistant. (SSPC C.7.1 seldom recommends acid etching.)

Acid etching is often accomplished with a 10% solution of hydrochloric (muriatic) acid or an aggressive citric acid. The concrete substrate should be pre-wet to assure uniform etching of the surface. One gallon of muriatic acid or citric acid should be spread over 50 to 75 Sqft (5 to 7 sq. m.) of concrete and allowed to stand for five minutes, coupled with aggressive scrubbing with a stiff bristle broom.

The surface should be immediately rinsed with fresh water to avoid formation of "bonded" salt deposits. This procedure should be repeated until the concrete has the texture of fine sandpaper. The surface should be thoroughly rinsed following each etching and the final surface checked with pH paper to assure that it has been neutralized.

Citric Acid - In place of using muriatic acid, citric acid can be effectively used to etch concrete surfaces. The use of citric acid offers some advantages, such as:

- Can be used at low concentration 5-10%
- Has a relatively moderate pH, 3.5 – 4.0.
- Low toxicity factor
- Safer to handle
- No harsh vapors during etching, does not interfere with other work in the immediate area
- Rinse and power wash

Citric acid can be purchased from, among others, The Pfizer Chemical Co., Pfizer Inc. Groton, CT 06340.

Neutralization - Regardless of which acid is used for etching the concrete substrate, it must be neutralized with clean water, preferably in two steps: first, a low-pressure rinse to remove spent acid volume, followed by a high-pressure rinse to remove embedded and surface residue. Pressure should be a minimum of 2500 psi at the nozzle for adequate results. The use of pressure washing assures the removal of the acid weakened and etched surface layer of concrete. This is conducive to promoting better adhesion of subsequently applied coatings, surfacing, toppings, etc.

ASTM D4262 - Standard Test Method for Determining the pH of Chemically Cleaned or Etched Concrete Surfaces. The test utilizes pH Test Paper in the final rinse water on the concrete surface. A strip of test paper should be dipped in the rinse water remaining on the surface. After the paper changes color, it should be compared with the color chart accompanying the paper to determine acidity or alkalinity. The pH reading of the fresh rinse water should also be taken. The pH reading from the rinse water on the concrete surface should not be more than 1.0 pH units lower or 2.0 pH units higher than the fresh rinse water. If it is, the surface should be further neutralized with fresh water and retested until the pH is acceptable. Two readings should be taken on random sections of every 500 Sqft (50 sqm) of concrete.

Advantages:

- Minimal equipment
- Fast operation
- Creates uniform profile (may require multi- applications)
- Can easily get into "tight places"
- Dust free

Disadvantages:

- EHS issues, especially with acid concentrates
- Does not remove acid resistant contaminates
- May not be "Legal" in some locations
- May require re-claiming of all spent bi-products, even if neutralized
- Introduces acid that could cause problems with corrosive damage, as an example to metal
- Introduces water to the concrete substrate that may be deleterious to the bond of some materials

NEEDLE SCALING

Needle scaling tools are used as concrete and masonry surface preparation. It is frequently used for work on edges, around penetrations and other tight spaces that cannot be accessed by larger equipment, such as shot blasting equipment.

Needle scaler removes contaminates by fracturing and pulverizing the surface of the concrete. The surface is impacted by the pointed tips of a bundle of steel rods that are pulsed by compressed air or hydraulics.

Advantages:

- Low cost, relatively low equipment cost
- Fast operation vs. wire brushes or hand chipping
- Removes most deleterious materials
- Can get into tighter places than any other mechanical methods of surface preparation

Disadvantages:

- Can give "false" sense that surface is properly prepared
- Slow, although faster than most other hand operations
- Extremely dusty

DIAMOND GRINDING

Diamond grinding is a method of cleaning and scratching the surface of concrete substrate by abrasion utilizing sanding disks or abrasive impregnated grinding wheels. This method produces a finely scratched surface finish free of surface laitance and contamination and a portion of surface fines. Extreme care must be taken to sand and grind "long-enough" and "deep-enough" into the concrete substrate to fully remove the laitance, especially cure-and-seal sealers. Concrete substrate "polish-gloss" must be removed, exposing the aggregate profile.

Advantages:

- Low cost, relatively low equipment cost
- Fast operation especially for light removal
- Removes most deleterious materials
- Can get into tighter places than most mechanical methods of surface preparation
- Dust free or dust reduction shrouds available

Disadvantages:

- Can give "false" sense that surface is properly prepared
- Prepared, when under-ground
- Slow, when deep removal is required
- Without excellent dust recovery, extremely dusty
- Fine dust particles can "pack" the concrete surfaces pores

which may block full penetration of the first resin coat.

ABRASIVE BLASTING

Abrasive Blasting is a method for cleaning and texturing the concrete substrate by impacting it with a high velocity stream of fine aggregate (silica sand or other medium) projected by compressed air. The blasting medium usually consists of hard, angular aggregates of a size range selected to be most effective. Sandblasting produces a textured, physically sound substrate free of surface contamination and fines.

The actual surface hardness of concrete and depth of desired profile should determine whether abrasive (silica sand or other medium) blast cleaning is the best concrete preparation method. Test areas should be tried, using the same equipment, air pressure, and abrasive you would intend to use. Production rates, dusting, and cleaning profiling (roughening) effects should be noted. EHS concerns regarding siliceous materials continues to reduce the annual use of silica sands, while other abrasives are seeing a corresponding increase in demand.

Larger abrasive grit sizes are used for preparing concrete than are used on steel. Grit abrasives having an 8 to 12-mesh size are recommended for heavy cleaning and profiling. If only the removal of concrete laitance is required, a 20-40 mesh size grit gradation is sufficient. Grit abrasives should have angular to sub-angular particle shapes and be at least a 6.0 on the Mohs Mineral Hardness Scale, where talc is a 1.0, and diamonds are 10.0. Grit abrasives having Mohs Hardnesses of less than 6.0 are too soft to clean and texture concrete at high production rates. Grit that fractures along cleavage planes, such as aluminum oxide, garnet, etc. remain angular and do not polish like silica sand.

The higher the impact velocity, the greater the rate of production and the greater the rate of breakdown-fracturing of the abrasive. Reuse of fractured abrasives, called the next generation or fines, should be mixed with the large abrasives.

The use of sand, grit, or shot impelled under high pressure gives a variety of results by adjusting:

- Abrasive Material (hardness and shape)
- Impact Speed
- Motion and Speed of the Nozzle or Machine

Advantages:

- Free of vibration
- Fast operation
- Very good keyed surface
- Dry surface
- Removes all material of the same strength or lesser strength

Disadvantages:

- Dust (pollution, silicosis, health hazards)
- Not very effective on rubber-like surfacing
- Through the high velocity of the abrasive particles, the impact on the rebar is so heavy that there is a change in the molecular matrix structure of the superficial layer of the rebar which cuts down on the rebar's resistance to corrosion

SHOT BLASTING

Shot blasting is an effective, relatively clean and dust-free (or dust-reduced) method for removing hardened films of contamination, and for texturing the concrete substrate by impacting the surface with high velocity metal abrasive. Shot blasting medium is available in a range of different sizes and a limited number of particle shapes. The blasting medium is thrown against the concrete substrate from a high velocity wheel. The abrasive scours the concrete surface, rebounds and is recaptured for continued use. The abraded surface fines and other contaminants are captured by a vacuum system.

The pulverized concrete, spent abrasives, dust and contaminants are removed by a separate vacuum dust collector. The reclaimed steel shot is then recycled to the blast wheel. Shot blasting machines are intended to be fully enclosed and provide an excellent means of cleaning and texturing concrete substrates, without the use of water or etching chemicals, and with a minimal release of airborne dust and contaminants. Shot blasting, using small shot, will provide a clean, physically sound concrete substrate, with a relatively uniform texture ranging from fine granular to a coarse sandpaper finish. Heavy shot can damage, micro-crack or micro-fracture the concrete substrate in a manner similar to other aggressive surface preparation methods. Shot blasting is particularly useful and cost-effective on large, unobstructed floors, decks, and other horizontal concrete surfaces. In addition, there is shot blasting equipment for vertical surfaces.

Normally, shot blasting is coupled with grinding or other methods of surface preparation, which is required for "can't get to areas" with shot blast equipment, such as under encumbered areas.

Preparing concrete surfaces using shot blasting generally results in concrete substrate removal of up to 0.125 inch (3.18 mm) per pass. If surface laitance alone are to be removed or if the surface is to be prepared for thin (< 35mil) coatings, the steel shot abrasive should be fine. Using fine shot, coupled with moving quickly, will produce a light etch on the concrete substrate similar to a brush blast. If a thick film topping or overlay is to be installed, a deeper texture must be achieved, which will produce surface profiles (IRCI-CSP) illustrated above.

Three parameters control the depth of surface profile or concrete removal:

- The mesh size of the shot (surface profile is proportional to shot size)
- The amount of shot flow to the surface, which is controlled (increased or decreased) by the operator.
- Speed of travel over the concrete substrate determines cut. The slower the travel speed the more concrete is removed

and correspondingly the greater the depth of cut.

Advantages:

- Free of vibration
- Fast operation
- Very good keyed surface
- Dry surface
- Removes material of the same strength or lesser strength
- Dust free

Disadvantages:

- Not very effective on rubber like surfacing
- Does Not Reach the Edges or Corners Effectively
- Horizontal Equipment Does Not Operate on Vertical Surfaces, such as curbs

SCARIFYING

Scarifying is a method for removing heavy buildups of surface contamination or other substances from concrete substrates, utilizing a mechanical action similar to horizontal planning. Scarifiers are heavy machines equipped with hardened steel cutters vertically aligned and arranged on a large, horizontal cylinder that rotates at high velocity. Scarification will impact and partially remove the concrete surface in closely spaced parallel lines. It must be used in conjunction with other approved methods of concrete surface preparation.

Advantages:

- Extremely aggressive
- Removes large amounts of material quickly
- Removes most deleterious materials
- Dust reduction shrouds available

Disadvantages:

- Can be highly abusive to concrete substrate, because of micro-fracturing of concrete after Scarification, Shot Blasting is recommended
- Requires a skilled operator
- Without excellent dust recovery, extremely dusty
- Must be used in conjunction with other methods of concrete preparation

UNSEEN BOND BREAKERS

Unseen bond breakers are problematic, because they are seldom seen or detected when installing a sealer, coating or flooring system. Crown Polymers has developed a contamination tolerant primer named CrownPrime WB Low Viscosity Epoxy Primer & Coating No. 8201, it is designed to be used when contaminates may not have been removed when the concrete surface preparation occurs. Use the primer If the concrete has been or is suspected of having been previously exposed to concrete curing agents or concrete densifiers, such as, sodium silicate, potassium silicate, lithium silicate or other contaminates.

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