Look Closely: Incorrect Assumptions Can Be Expensive

By Floyd Dimmick Sr., Technical Director Crown Polymers, LLC.

Crown Tech Support: Series 4

"You don't concentrate on risks. You concentrate on results.
No task is too great to prevent the necessary job from getting done". Chuck Yeager

All concrete surfaces, new or old, require surface preparation prior to installation of polymer-cementitious or polymer-overlays. It does not matter if the overlay is neat, without aggregate, or an aggregate build-up system.

Because proper surface preparation can be time consuming, some contractors think shortcuts are okay. This is an assumption that will cost the contractor and the property owner difficulties and the money to reinstall a new floor, when inadequate preparation causes the overlay to fail.

Proper surface preparation includes more than superficial cleaning of the floor or deck surface. Most polymer manufacturers provide a checklist for use during initial inspection. It is critically important to follow this checklist when bidding a project. Overlooked details can result in poor preparation that in all likelihood will cause the overlayment to fail. This will happen regardless of the quality of the polymer used, or the skill of the contractor's crew.

Surface Preparation Methods

Seldom can one method satisfy all the requirements for proper cleaning and preparing concrete surfaces. Various methods have advantages and disadvantages. Therefore, different methods should be considered individually, or in combination, to achieve the best possible result.

Surface Preparation Methods Include:

Acid & Caustic Etching*
Detergent Scrubbing*
Fatty-acid Emulsification*
Low-pressure Water Blasting*
Sanding*
Scraping*
Needle Scaling*
Jackhammers*
Flame cleaning
Scarifying

Milling / Horizontal Planing
Grinding
Abrasive Sand / Grit Blasting
Abrasive Steel Shot Blasting
Abrasive high pressure water blasting
Dry ice blasting
Scabbing**
Bush hammering**
Steam cleaning **
Stripping**

** Not a stand-alone method*

*** Not a recommended method*

Appropriate Surface Preparation

Appropriate surface preparation is a critically important factor for the immediate and long-term performance of any polymer overlay system. It is the responsibility of the contractor to inspect the concrete surface and provide a clean, properly prepared substrate. The ultimate goal of surface preparation is to achieve bond.

Specifications for surface preparation include the following:

1. Inspection and sounding of the concrete
2. Removal & replacement of the sub-standard concrete
3. Decontamination of the concrete surface
4. Creation of the correct surface profile
5. Repair of surface grades and irregularities
6. Testing the cleaned concrete for adhesion and vapor emissions

1. **Inspection and sounding of the concrete.** Determine the general condition, soundness, moisture vapor emissions, contaminants, birdbaths, low or wrong grades for drainage and the best methods for the surface preparation. All these are critical decisions required to accurately generate price quotations and assure satisfactory results. A thorough inspection will provide the information needed for selection of proper tools, equipment, and the overlay system best suited for the job.

2. **Removal and replacement of the sub-standard concrete.** This must be accomplished prior to the placement of the polymer overlay. Techniques for shallow surface removal include grinding, abrasive sand / grit blasting, abrasive steel shot blasting and abrasive high pressure water blasting. Deeper concrete removal often requires saw cutting the perimeter of the deteriorated area and/ or breaking the concrete with jackhammers. The conditions in the work area often determine the selection of the equipment and techniques used. All floor sections where concrete has been removed should be replaced with polymer-concrete (PC) or epoxy polymer concrete (EPC), in order re-establish a level surface or proper grade. The best reasons for using PC or EPC is the compatibility and depending on the patch formula selected, it could overlayed within hours after placement with the floor or wall system. Follow the polymer manufacturer's recommendations for combining the above two systems.

3. **Decontamination of the concrete surface.** This step requires the removal of fatty acids, oils, grease, wax, petroleum products, acids and other contaminants. Once the contaminant(s) is known, an emulsifier, detergent, heavy duty cleaner / degreaser or chemical will be selected. To accomplish the contaminant removals follow the manufacture's recommendation of use and equipment selection for a successful application. The cleanup requires scrubbing, low, or high-pressure water cleaning equipment to wash off the residues of the emulsification process. After cleaning is complete, although the surface may look clean, the concrete will need to be abrasive steel shot blasted for final removal of any remaining animal fatty acids, blood, microbes or cleaning solutions. Grinding equipment maybe used, if the fatty acids have been removed from the concrete successfully. However, if the fatty acids have not been removed, grinding is not recommended because it will drive the fatty acids present deeper into the concrete creating adhesion problems. At this time, the final substrate surface profiling will be completed. Equipment that creates dust should have a vacuum attachment and dust collector. Caution: Do not use solvents to clean the concrete; they drive the fatty acids deeper into the substrate creating adhesion problems.

Advances in Epoxy Formulation

During the 60's and 70's it was common for polymer manufactures to recommend that the pH of concrete be reduced below 10 and above 7 on smooth concrete applications. As manufacturers, developed improved epoxy formulas, the acid etching process reduce became unnecessary. In fact, many of these new formulations achieved not only a mechanical bond, but also a chemical bond to the cement molecule creating a true monolithic bond to the concrete. These new technologies allowed epoxy applications after using only abrasive cleaning methods, thus eliminating the chemical acid etching step and substantially reducing labor costs. Caution: Do not mix up caustic and acid etching to remove contaminations that have been spilled on concrete surfaces. In corrosive environments, the etching process is still required.

Important Test for Cleanliness
When portland cement has not been exposed to oxidation or chemical etching, it has a pH of 11 to 14. Many of the contaminants mentioned above are neutral or acidic. They reduce the cement pH levels from a higher alkaline state, which weakens or destroys the bonds to the aggregate, thus compromising the concrete mass and its soundness.

Another important soundness test is to confirm that the pH level of the cleaned concrete has been returned to a pH range of 11 to 14 after the abrasive portion of the surface preparation. If it has not been returned, this indicates that there are active fatty acids present in the concrete and additional emulsification and removal is required.

To test the concrete's pH level use Litmus paper and distilled water. The test should be conducted in multiple locations. The contractor should perform this simple test every time fatty acid removal is required. The Litmus pH paper test is the same procedure used in your garden to test the soil acidity or alkalinity. Pour a small amount of distilled water, about 2 inches in diameter, on the cleaned concrete surface. Use a stainless steel spatula; rub the water into a paste by dissolving some of the cement molecules. Tear off about two inches of the Litmus paper. Lay the end of the paper, about ¼ inch, into the solution and allow it to wick up into the paper. Do not rub the paper into the solution a false reading will occur. As the solution is wicked up into the paper, the color will change. Immediately match the new paper color with the color chart provided with the Litmus paper. Record the reading and the location. If the pH is 10 or lower, addition surface preparation will be required to assure a lasting bond of the patch or overlay. In areas where contaminates cannot be removed, the contaminated concrete must be removed and replaced as described in section 2, above.

In addition, when the water is poured on the surface for the pH test it should spread out immediately. If it stands upward in a bead before spreading over a larger surface area, this indicates that there are oils, grease, fats and fatty acids still present in the concrete. More cleaning is required.

4. **Development of the correct surface profile.** This step is critical to many polymer cementitious overlays. Most epoxy polymer concrete formulas do not have the same critical profile requirements to establish a good mechanical and/or chemical bond to the substrate. The surface profile for both polymer systems is dependent on the system used and its application in locations such as trenches, walls, ceilings, sumps, shafts, pipelines and floors. Each could have unique requirements, as recommended by the polymer manufacturer. It's important to remember, there are no cure-all systems, and therefore the polymer manufacturer recommendations are your best to guide your work.

   Concrete substrate profiles must comply with ICRI Guidelines No. 03732. However, other considerations such as the thickness of the overlay, the polymer type of overlay, the equipment and tools selected, and application methods will contribute to the smoothness or aggressiveness of the surface profile. Another factor that must be considered is the type of traffic and abuse the overlay will be subjected to on a daily basis.

5. **Repair of surface grades and irregularities.** New or old concrete surfaces may require birdbath leveling, the creation of new grades to move water off the floor or to correct drainage problems. A detail that is often missed is the puddling below the wall cove adjacent to the floor.

   Re-grading is a simple way to reduce maintenance and eliminate the surface contamination that can result from poor drainage. Thinner overlays may require regrading of the entire surface in order to establish proper drainage. By contrast, thicker overlays alone may fill areas that are relatively shallow.

Typical surface irregularities include holes, bug holes, spalls, cracks, deteriorated joints, slopes, and areas near the transition zones, drains and doorways. Often, proper surface preparation will correct or eliminate these defects. However, all irregularities must be repaired prior to the overlay placement.

Contractors attending the Crown Polymers Polymer Overlay College learn simple and efficient methods of correcting problematic floor conditions. Access to these valuable techniques is one of the many benefits that result from Crown's hands-on training program.

Crown Polymers offers repair and overlay products that are entirely compatible, assuring a durable monolithic surface and extended floor life. Typically, when properly installed, Crown's build-up overlay floor systems will last two to three times longer than the original concrete floor.

Many of Crown's systems are extremely fast curing, allowing placement of the next polymer lift within two to six hours. Savvy contractors learn quickly that fast curing and easy handling products from Crown Polymers, when compared to competitive products, allow projects that would otherwise require two or three days to be completed in a single day.

6. **Testing the cleaned concrete for adhesion and vapor emissions.** Typically, these are the final test procedures before any polymer repair or overlay placement. There are three bond tests and one vapor test.

   Tensile pull tests are used when the property owner requires test data for verification of the concrete strength and soundness. There are two acceptable test methods used for this work:

1. **ASTM D4541 -** Standard Test Method for Pull Off Strength of Coatings Using Portable Adhesion Testers. This is a tensile strength test that bonds a steel plug to the concrete surface and, upon the adhesive developing sufficient strength, the plug is pulled until either the concrete fails, the adhesive fails or a combination of both failures occur.

   The tensile strength and method of break are recorded. The typical requirement is a minimum of 250 psi. However, abusive projects with higher quality concrete often require up to 500 psi as the minimum acceptable value. The final consideration for passing the test is a 100% concrete break, without cohesion polymer bond line failure.

2. **ACI 503.1 -** Standard Specification for Producing a Skid Resistant Surface on Concrete by the Use of a Multi Component Epoxy System. This is a tensile strength test similar to the above ASTM D4541. It is the oldest test method used by contractors. The basic difference between the two tests is the plug diameter size attaching to the concrete. ASTM D4541 uses a one-inch diameter steel plug and the ACI 503.1 method uses a two-inch diameter steel pipe cap ground smooth. The data is recorded the same way for both test and criteria are the same for passing.

   I believe the reason the ACI 503.1 test method is more valid is because it test a larger surface area, whereas, a one inch diameter test could possibly only measure the results of a ¾ inch aggregate and not the cement paste, which may skew the overall results.

Testing the aggregate will typically lower the concrete values. In addition, the bonding adhesive should be the same polymer intended for use in the overlay to be placed on the concrete surface. This approach will validate the overlay's ability to become a monolithic part of the concrete. The exception is when a membrane is required. That is, typically membranes do not have the same adhesive bond strength as primers and base coats. In this situation, a stronger polymer adhesive should be acceptable for accurate testing values.

3. Shear Testing This is the most common test used by contractors on project sites. It does not have an ASTM or other association standard, however many polymer manufacturers create their own standard for contractors based on years of experience. It's fast and gives the contractor the data he or she needs to determine the concrete cleanliness and soundness. It does not give shear values measured in psi or other units as provided by tensile-pull tests. Nevertheless, it clearly offers indications and helps determine if additional surface preparation is required to obtain proper adhesion. Passing this test requires a 100% concrete break, without cohesion polymer bond failure.

Crown Polymers has a data bulletin, Crown Polymers Shear Cup Test Method for Testing the Cleanliness & Adhesion of Concrete". This information is available upon request. Many contractors have reported that once they started using the shear test regularly on projects, overlay adhesion failures were virtually eliminated. This testing method may be the most important part of surface preparation for polymer overlays of any thickness.

4. ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride Moisture Emissions Test. This test makes a quantitative evaluation of vapor emissions from the concrete. It is a test that the contractor can place on the floor and monitor the results. When vapor is suspected, different areas on the floor can be cleaned by steel shot blasting and the concrete tested with ASTM F1869 to determine if the vapor emission exceeds 3 pounds of moisture per 1,000 square feet per 24 hours.

Three tests are required for the first 1,000 ft2 and 1 additional test for every 1,000 ft2 of floor surface. Crown Polymers has adopted the international industry standard of not-to-exceed 3 pounds of vapor moisture per 1,000 square feet per 24 hours for all of its floor systems.

If the test exceeds 3 pounds, a 100% solids penetrating liquid epoxy needs to be applied, as an upper concrete surface vapor barrier, after surface preparation has been completed. Upon completion of the application of CrownCote Vapor Barrier, Product No. 303, it will be allowed to cure overnight before repairs, patching, re-grading or placement of the polymer overlay. CrownCote Vapor Barrier has a successful record of stopping vapor transmission. It creates a permanent barrier because of its deep penetration into the concrete. In addition, the cured epoxy strengthens the upper surface area of the concrete, and it will never re-liquidify.

For further information on vapor emissions request my two published articles on the subject: Vapor Trails: How Water Gets Through Slab-on-Grade Concrete, and "Vapor Trails: Battling Water Vapor in Concrete".

Four Decades of Experience

This white paper is based on over four decades of polymer industry experience and is based on hard evidence gathered working with contractors and serving on association committees concerned with polymers and concrete. I have no connection with any surface preparation manufacturer or marketer. Crown Polymers single motivation is to share our knowledge and provide you with information on how to obtain the best possible result. In future white papers I will address different methods of surface preparation outlined in this document.

Learning to forget the past will get us to the future
Our strategies are worth adopting. They can improve the performance of your company by learning similar information addressed in this white paper. Knowledge is a competitive advantage. Become the expert in your market. Attend a Crown Polymers "Polymer Overlay College" A Hands-On Training Experience.

At Crown Polymers, learning and training never stops. Individuals who adopt and apply the concepts developed by Crown's team of experts are able to independently devise "LEED® Green" market-specific strategies that are sure to increase sales.

To enroll in the next session, contact us today at 888.732.1270
or email info@crownpolymers.com for details.

Floyd Dimmick, Sr. is co-founder and the Technical Director of Crown Polymers, a manufacturer of concrete repair products and decorative, institutional, education, industrial and commercial floor and wall systems. He has designed and applied polymer products for over 45 years, and has received patents in the USA and Canada. He teaches 10 to 12 polymer classes for contractors annually and has numerous published papers and book chapters on concrete repair with polymers. He is a member and was past chairman of polymer overlay committees of ACI and ASTM.