Concrete Contamination and Its Effects on Coating Work

Concrete is a common construction material for industrial structures. However, these structures will deteriorate due to exposure to certain contaminants unless properly protected with coating systems. And these same contaminants, unless mitigated prior to coating application, may cause premature coating system failure. This month’s Applicator Training Bulletin discusses various types of concrete surface contamination and techniques for removing contamination prior to coating application.

What Is Contamination?
Contamination, quite simply, is the presence of undesirable materials. In the case of concrete substrates, contamination may consist of the effects of deterioration, such as from exposure to chemicals; visible contaminants, such as oil, grease, or dirt; or non-visible contaminants, such as moisture, acid, or chemicals.

If left in place, contaminants may degrade concrete substrates. A few of the more common concrete degradation mechanisms caused by contaminants include acid attack, alkaline reaction, chloride-induced deterioration, and the effects of oils, fats, greases, and sugars.

Acid Attack
The Portland cement in concrete is an alkaline material. It can react with various types of acids to form salts that can cause the cement binder to dissolve, leaving exposed aggregate.

Acid attack is most common with mineral acids such as hydrochloric, sulphuric, and nitric. For example, hydrogen sulphide, which is commonly found in oil and petrochemical plants, can react with moisture to form sulphuric acid, which can attack cement. Sulphur is found in coal and oil. When these materials are burned, the sulphur can react with moisture to form sulphurous and sulphuric acids. Sulphuric acid also is generally found in chemical manufacturing plants and certain industrial wastewater plants, as is hydrochloric acid.

Even organic acids can attack concrete. Humic acid, a by-product of decaying plants and animals, can chemically react with the concrete surface. This could be a problem on concrete highway bridges, while in food and beverage plants, lactic acid, which is found in milk, and citric acid from fruit could also attack concrete surfaces.

Alkaline Reactions
Although the cement binder is alkaline, exposure to high concentrations of hot, alkaline materials such as a sodium hydroxide solution can dissolve some of the binder in the concrete. Alkaline attack of concrete is typically found in soap manufacturing plants or near lime kilns such as those at pulp and paper mills. Its effect is similar to acid attack, with the cement binder being dissolved to expose the concrete aggregate. If silicate aggregates are used, they might also be dissolved or attacked. Sodium hydroxide, also known as caustic soda, is used in soap manufacturing, paper production, bleaching and dyeing, and other manufacturing processes.

Chloride-Induced Deterioration
Normally, steel imbedded in concrete initially corrodes to form a tightly adherent oxide film. This film protects the steel from further corrosion provided it remains intact, which it does because of the high alkalinity in the concrete. However, if chloride salts, oxygen, and water penetrate the concrete, they can destroy the protective oxide film on the steel reinforcement and cause further corrosion. Moreover, the expansion that occurs when rust forms on the steel can cause the concrete to crack and spall, breaking off in layers, and rust may bleed through the cracks in the concrete. Chloride-induced corrosion can occur anywhere chloride salts are present, such as in a marine environment, which is naturally salty; on bridge decks and in parking garages that are treated with deicing salts; or on concrete structures that are in contact with chloride-containing soils.

Oils, Fats, and Greases
Oils and fats can cause two problems with concrete. One is attack; the other is contamination. Crude oils that are high in sulphur can cause acid attack, especially when water is present. Also, sulphur-oxidising and sulphate-reducing bacteria have been known to attack the cement binder in crude oil storage vessels made of concrete.

Oils, fats, and fatty acids also can react with the alkali in...
the cement binder, producing a soap and glycerin that can turn it into powder. Oils, fats, and fatty acids are found in vegetable oil processing plants, slaughterhouses, and meat processing plants. This type of attack on concrete has even occurred in restaurant kitchens.

However, even if oils do not attack the concrete, they can contaminate concrete surfaces and affect adhesion of paint. For instance, oil leaks from machinery in manufacturing plants of many kinds can contaminate the concrete floor, making it unpaintable.

**Sugars**
Sugars found in sugar cane and beets, milk, and fruits can also react with the cement binder, causing it to degrade. This is especially true when the products are heated. Sugar attack is found in sugar refining and processing plants.

**Defects and Other Contaminants**
Some other contaminants may not structurally degrade the concrete substrate but may cause premature failure of the coating system applied to the concrete. In addition, defects in the concrete may affect its coatability. These problems include the following:

- **laitance**: a layer of weak and non-durable material containing cement and fines from aggregates;
- **efflorescence**: a white crystalline or powdery deposit on the surface of concrete resulting from lime or calcium hydroxide leaching out of the concrete mass;
- **curing agents**: liquid coatings applied to the surfaces of newly placed concrete to retard loss of water during concrete curing; and
- **form release agents**: coatings applied to forms used in concrete placement for easy form removal after curing.

Other problems include voids and other surface irregularities, mildew, surface hardeners, waterproofing compounds, concrete spatter, dirt, and dust.

**Identifying Surface Contaminants Through Site Investigation**
Before specifying or performing coating work on concrete surfaces, it is imperative that a careful site investigation be performed to identify potential sources of contaminants. This process involves both physical testing and surface chemical testing. The first step is to hold discussions with the owner to determine exposure conditions at the facilities. This would include the chemicals and materials used at the site. It is important to remember that some sources of contamination, such as airborne contaminants, may origi-
nate off site. The site investigation should include a visual evaluation of the concrete for signs of deterioration and contamination. Signs of deterioration include cracking, spalling, exposed aggregate, powdery concrete, and discoloration.

**Physical Testing**

Physical testing may need to be performed as part of the site investigation. One major concern is the soundness of the concrete. Inspection should be done by the engineer before the painter ever gets there, but the painter should be aware of the inspection. A common method to check the soundness is to lightly tap the surface with a hammer. Sound concrete will “ring,” and the hammer will rebound if held lightly. A “thudding” sound or no rebounding of the hammer indicates deterioration or an underlying disbonded layer. Large floors can be examined more quickly by dragging chains over the surface and listening for hollow sounds. Tools such as a scraper, screwdriver, or knife can be used to probe areas where deterioration is visible or suspected. The intent is to determine the depth and extent of soft or deteriorated concrete.

**Surface Chemical Testing**

Surface chemical testing may be necessary if the presence of non-visible contaminants is suspected. Non-visible contaminants include concrete surface hardeners, curing agents, form release agents, waterproofing compounds, and oil or grease. As noted, acids from a variety of sources as well as mildew also can cause contamination.

There are two ways of testing for these contaminants. One is a water drop test. A drop of water is placed on the surface; if it beads, that means a surface contaminant probably is present. A better method is to place a 10% hydrochloric acid solution (as much or as little as desired) on the surface. If no contaminants are present, the solution will fizz as the hydrochloric acid reacts with the cement binder. However, contaminants would block the acid from contacting the surface, and so no fizzing would occur.

In many cases, it is not necessary to identify the invisible contaminants, since proper surface preparation techniques will remove them.

If acid attack is suspected, it may be necessary to check the pH of the surface. This can be done by wetting a piece of pH or litmus paper and placing it on the surface. Alkaline solutions will turn the litmus paper blue; acids will turn it red. However, it is better to use pH paper or sticks because they... Continued
give a more exact indication of the acidity or alkalinity of the surface. Both pH paper and sticks change colour, depending on the pH level of the surface being tested, and the colour can be compared to a chart provided by the manufacturer.

Mildew should be suspected if dark stains are present. There are two ways to identify mildew. One is to examine the stain under a 10-30 power field microscope. Mildew is a living organism that can be identified by its branch-like structure. Another way is to place a drop of sodium hypochlorite (a commercial bleach will do) on the surface. This will kill the mildew and cause the stain to disappear.

If the concrete is deteriorating, it may be necessary to determine the depth of the deterioration by taking a core sample of the concrete and sending it to a laboratory for a petrographic analysis. The sample is treated in the laboratory with various chemicals and examined under a microscope. The laboratory report should identify the type of deterioration, its depth, and its effect on the concrete’s durability.

Preparing Contaminated Concrete

It may be necessary to remove deteriorated concrete prior to surface preparation and coating. Removal is usually done when there has been chemical attack on the concrete or corrosion of the reinforcing steel. Deteriorated concrete can be removed using pneumatically driven, hand-operated jackhammers or chisels, scabblers, scarifiers, or other appropriate power tools. The location and depth of removal should be determined before work begins. The choice of removal method depends on the type and extent of deterioration.

When the deterioration is deep, jackhammers or pneumatic chisels are preferred. Scabblers remove concrete by

Continued
impact with piston-driven heads that pound on the surface to chip and pulverise it. Scarifiers use rotary action of cutters mounted on fast-turning wheels or drums. Scarifiers are usually used when thin layers, i.e., 3 mm (1/8 in.), of weakened or deteriorated concrete have to be removed, while scabblers can remove concrete to a slightly greater depth per pass. For small areas, hand-held impact chipping or scaling hammers or needle guns are used. Large areas may be more efficiently removed with hydrodemolition equipment or milling machines.

Oil and grease contamination up to about 6 mm (1/4 in.) can be effectively removed by scrubbing the surface with a commercial degreaser or cleaning compound. After these products are used, the surface must be washed to remove the cleaning agent. If the penetration of the oil or grease is deeper than 6 mm (1/4 in.), then the concrete will have to be removed to the depth of penetration.

Many of the non-visible surface contaminants mentioned above (such as laitance, efflorescence, form release agents, etc.) must be removed prior to coating as part of the normal surface preparation for concrete. This includes methods such as mechanical cleaning, abrasive blasting (both dry and wet) and waterjetting. The purposes of these methods are both to remove contaminants and roughen the surface to promote coating adhesion. Detailed information on these surface preparation methods is contained in SSPC-SP 13/NACE No. 6, Surface Preparation of Concrete.

**Conclusion**

To preserve the integrity of concrete and to facilitate the adhesion of coating systems, surface preparation techniques and methods should be specified to remove a broad range of contaminants and to provide an appropriate level of surface profile and cleanliness for coating application.

**Additional Sources of Information**

- The Fundamentals of Cleaning and Coating Concrete by Randy Nixon and Dr. Richard Drisko (SSPC Publication 01-10)—www.sspc.org
- American Concrete Institute (ACI)—www.aci-int.org
- International Concrete Repair Institute (ICRI)—www.icri.org

**Coming Next Month:**

Coatings and Cathodic Protection