Specifying High-Performance Coatings for Concrete

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Coating above-grade exterior concrete walls is an effective and economical way to both decorate and protect concrete. Monotonous gray concrete can be turned into colors appealing to the eye, adding warmth and scale to an otherwise unattractive facade. Texture can be added to give liveliness to an otherwise flat and unappealing surface, and depth and accent features can be added at a fraction of what it would cost to create them with form work.

- Besides adding color, texture, and form, high-performance acrylic-textured coating systems provide a layer of protection against concrete deterioration. The success of these systems, however, depends on a number of factors, including:
- surface preparation;
- the chemical and physical condition of the concrete substrate;
- priming;
- product selection (coating must possess right properties for service conditions); and
- professional application under favorable drying conditions.

Surface Preparation

The surface preparation section of the coating specification is critical to the overall success of the project, and warrants as much attention as actual coating selection. Without proper surface preparation, the performance and aesthetics of even the best coating can be compromised. The first rule for coating any concrete surface is to provide a clean, sound, and true surface before applying the coating. This means repairing any surface defects or planar irregularities that could detract from the appearance of the finished wall surface, and removing form release agents and any other bond-inhibiting material.

Projecting fins or other protrusions can be removed mechanically by sawing or grinding. Small holes, pits, and voids can be repaired with a sacking mortar rubbed into the holes and damp cured for several days. Sacking mortars can be field-blended sand/cement mixes, or proprietary materials available from the coating manufacturer. Bugholes, honeycombs, form-tie holes, and other voids can generally be repaired with field-mixed or proprietary patching materials.

A distinction should be made between shallow patches (i.e. surface pitting) and deep ones (i.e. severe spalls), and the correct material must be specified for each condition. For shallow holes, a field-blended sand/cement mix or polymer-modified portland cement repair mortar can be used. For deeper holes or patches (greater than 19 mm), a field-mixed dry-pack portland cement mortar or pre-blended polymer-modified portland cement mortar available from the coating manufacturer can be used.

For large patches, the repair area has to be prepared by cutting a square or rectangular section around the defect to its full depth, followed by the removal of any surface contamination and loose/friable material. The repair area is dampened with water until thoroughly damp, but free of puddles or standing water. The mortar is then placed and damp cured for a minimum of 48 hours. Multiple passes of the mortar may be necessary for extra-deep patches, depending on the thickness for which the mortar is designed. Where multiple passes are made, the surface of the first layer of repair mortar is scratched to achieve good mechanical keying of the second layer of material.

Surface deposits on concrete, such as efflorescence, must be removed by cleaning or wire brushing. A detergent wash with a trisodium phosphate detergent and hot water followed by thorough rinsing with clean water is generally sufficient to remove form oil, dirt, and grease from the surface. When the form release agent cannot be removed from the surface with a detergent wash, or when grease, oil, or dirt has penetrated the surface of the concrete, then more aggressive surface preparation methods, such as steam cleaning or abrasion, are needed.

Acid cleaning followed by neutralization and rinse is often prescribed for preparing concrete for coatings, but the potential hazards and complications involved with acid neutralization make this cleaning method the least desirable. Abrasive methods, like grinding and water/sandblasting, remove curing compounds and weak layers at the surface of the concrete (laitance), but they are costly, at times impractical, and can alter the substrate's surface profile. The desired texture may not be achieved when the concrete is coated, and may require subsequent resurfacing to create a smooth surface.

When new concrete is to be finished with coatings, then, a removable form-release agent should be specified, as well as a method for its removal. Applicable regulatory requirements, practical constraints, and project scheduling should also be taken into consideration.

Shallow surface cracks, such as those caused by plastic shrinkage, can be repaired with treated glass fiber reinforcing mesh embedded in the coating manufacturer's proprietary crack treatment material. Drying shrinkage cracks, or any type of structural crack, require special analysis and treatment before coating. Treatments can vary from epoxy injection for repairing structural cracks to saw cutting and sealing with flexible joint sealant for dynamic cracks.

Depending on the root cause and nature of cracks, the chosen repair method and coating system can entirely span over the cracks. In some cases, though, it may be impossible to span cracks successfully without their telegraphing through the finished surface. These cases require special detailing or alternate systems. Metal lath and stucco or EIFS (exterior insulation and finish systems) may be suitable alternatives.

Concrete Condition Check

After repairing surface defects and cracks, and removing surface contamination, the next step is to check the alkalinity(pH)o ft hec oncretes urfacea ndt hem oisture content of its mass. Highly alkaline surface conditions can be detrimental to coating adhesion, color uniformity, and long-term durability. Concrete is alkaline by nature, but this property decreases over time with exposure to moisture and carbon dioxide in the atmosphere(carbonation). For this reason, a minimum of 28 drying days is always recommended before coating concrete surfaces.

Depending on weather conditions, curing, and the thickness of the concrete, even 28 days may be insufficient time for achieving a neutral surface. Furthermore, the cleaning agents used to prepare the concrete surface also influence surface alkalinity. Patching materials, particularly those with high lime concentration, can produce 'hot spots' where alkalinity is high in comparison to older concrete. Under ideal circumstances, the surface pH should be 6–9 for acrylic-textured coatings.

Given the highly alkaline nature of concrete, the potential for a variety of surface alkalinity conditions to exist along an expanse of concrete, and the practical constraints of construction scheduling, the best means of safeguarding against the potential adverse effects of high pH is to use a primer/sealer to create a neutral surface. Many coating manufacturers produce primer/sealers with this purpose in mind. The primer/sealer acts as a barrier over the alkaline concrete surface; in effect, masking the finish coating from the alkaline surface condition. So long as no more water migrates to the surface, the finish is protected from the potentially adverse effects of alkalinity.

The moisture content of concrete should be checked before coating, as excess moisture encourages the continued migration of calcium hydroxide and other soluble materials in the concrete to the surface. When migration occurs after the finish coating is in place, it can suffer not only from the effects of alkalinity, but other deterioration mechanisms. Excess moisture can condense or create vapor pressure behind the coating, both of which can cause blistering or peeling. In freeze/thaw climates, excess moisture behind the coating can cause spalling. Even when the coating is highly vapor permeable and allows such moisture to pass through, cosmetic damage like efflorescence can occur to the finished wall surface.

A probe-type moisture meter can be used to obtain quantitative readings of moisture in the concrete. While some moisture can be tolerated by acrylic-textured coatings, a dry reading is always preferable to avoid problems. Another simple test one could perform is outlined in ASTM International D 4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method. Plastic film is taped over the concrete surface and left for 16 hours, then inspected for the presence of moisture or a darker color of concrete. These relatively simple checks of the concrete's condition after it has been prepared can prevent problems later on, and can be specified as part of the coating installer's scope of work.

Priming

Adhesion to prepared concrete is enhanced with a primer/sealer that penetrates and seals the surface. It is the hidden workhorse of the coating system, because it:

- establishes firm adhesion to the prepared surface;
- creates a more uniform substrate absorption, which prevents uneven drying with consequent color and texture differences in the finish coating;
- protects against the effects of a highly alkaline substrate; and
- adds to the overall water penetration resistance of the coating system.

Specifying the correct primer/sealer over a properly prepared concrete surface substantially improves the coating system's performance and aesthetics.

Coating Selection

Both aesthetic and functional properties must be considered when selecting coatings for concrete walls. The main functional requirements are adhesion, and resistance to the effects of weather and mechanical stresses. Table 1 summarizes important physical and mechanical properties to consider when selecting coatings for concrete walls, and applicable ASTM standards for measuring performance.

Resistance to UV (ultraviolet) degradation is an important functional requirement of the finish coating. UV degradation manifests itself in the form of chalking, fading, and in worst case scenarios, loss of flexibility and cracking of the coating. When specifying coatings, the specifier must investigate the weathering data furnished by the coating manufacturer—both duration and type of accelerated weathering. Most manufacturers develop their coating formulations in part on the basis of accelerated weathering tests, outdoor fence exposures, and long-term, real-world outdoor exposure studies. The manufacturer should be able to provide this data, as well as independent laboratory test data, and cite references in both climatic and exposure conditions similar to the project under consideration.

Table - 1 : Performance Tests for High Performance Acrylic-textured coatings for Concrete

No Sr.	Test	Method	Description
1.	Accelerated Weathering	ASTM G 53	Measures resistance to U V degradation and cyclic water exposure
2.	Adhesion	ASTM D 4541	Measures tensile bond strength to substrate
3.	Water Penetration Resistance	ASTM E 331, ASTM E 514, Fed Spec TTC-555B	Measures rain water penetration resistance
4.	Water Resistance	ASTM D 2247	Measures resistance to prolonged water exposure
5.	Water Vapor Permeability	ASTM E 96	Measures water vapor diffusion rate
6.	Salt Spray	ASTM B 117	Measures resistance to salts
7.	Abrasion Resistance	ASTM D 968	Measures resistance to wear from abrasives
8.	CO_2 Diffusion Resistance Coefficient	EN 1062-6	Measures resistance to diffusion of carbon dioxide
9.	Mildew Resistance	ASTM D 3273	Measures resistance to surface mold growth
10.	Flexibility	ASTM D 522	Measure resistance to cracking and flexibility
11.	Tensile Strength	ASTM D 412	Measures tensile properties– tensile stress, tensile strength and yield point
12.	Elongation	ASTM D 412	Measures elongation and recovery after elongation

Note: This list is by no mean comprehensive, but covers some of the important performance criteria. Other tests may apply depending on project requirements.

Resistance to water penetration is important for preventing the degradation of the coating, and providing long-term concrete protection. In the event water gets through the coating, a number of possible harmful effects can be set in motion. Excess water behind the coating will migrate to the exterior and exert pressure, causing blisters or peeling. As excess moisture migrates to the exterior, it carries soluble salts from the concrete that become efflorescence stains upon exposure to the atmosphere. Finally, water penetration can accelerate concrete deterioration mechanisms: carbonation, corrosion of reinforcing steel, and spalls from freezing.

Resistance to cyclical wetting/drying and prolonged wetting are other types of performance criteria to include int hes pecifications.N ortherne levations,f ore xample, generally experience prolonged wetting because sun exposure is minimal. Coastal exposures, on the other hand, may experience longer and more frequent condensation cycles on the face of the coating. The frequency of wetting/drying along with wetting from rainfall accelerates coating wear.

While resisting water penetration and deterioration from the effects of cyclical or prolonged water exposure, the coating must also be water vapor permeable. In the event water gets behind the coating, permeability can prevent blistering, peeling, and in worst case scenarios, freeze/thaw damage. Impermeable finish coatings generally should not be used, and a balance between liquid water penetration resistance and water vapor permeability should be sought in the finish coating.

Once the basic performance of the coating has been evaluated, one can fine tune the selection based on the unique exposure conditions of the project. For example, resistance to salts is an additional performance requirement to be included in the specification in coastal environments with salt-laden air. It may be wise to specify abrasion resistance for high-traffic areas, and hot, humid climates generally demand extra algae and mildew resistance while dry climates do not.

Coating Application, Addition of Features, and Mock-up

The final step in a successful coating system over concrete is the application. Contractors should be pre-qualified and selected on the basis of past performance, financial stability, quality orientation and training, familiarity with the specified materials and application techniques, and the ability to meet the demands of the project. The contractor should possess the manpower and equipment for the size of the project and type of coating system specified.

Acrylic-textured coatings are generally applied with gravity-feed, hopper-type spray equipment, or proprietary equipment available from the coating manufacturer. It is important to specify the conditions under which the coating is to be applied to ensure adequate drying and proper film formation. This typically means ambient and surface temperatures above 10°C and not higher than 32°C , and humidity not higher than 80 percent for water-based, acrylic-textured coatings.

While these temperature ranges do not represent the absolute extremes at which coatings can be applied, they optimize conditions for good film formation and drying, thereby minimizing drying stresses and improving long-term performance. The manufacturer should be consulted for advice on temperature and humidity limitations, as well as appropriate spray application equipment.

Relatively simple and economical to install, adding EIFS feature bands (i.e. decorative trim around window penetrations or cornice profiles) before the coating application can greatly enhance a structure's visual appeal. The finish coating is then applied to the EIFS feature to obtain a monolithic texture and color, or a contrasting texture/color is applied to accentuate the feature. (Note: limitations do exist on the thickness of EIFS that can be applied.)

A mock-up should be constructed whenever possible as the basis for accepting all aspects of the coating system's work and appearance. Concrete tolerances and surface condition, surface preparation techniques and materials, primer and finish coating application technique and materials, application of features, and final finished appearance can all be evaluated by the designer or owner in a mock-up. Along with a visual assessment, the coating's adhesions houldb et esteda ndv erified.A STMD 4 541, Standard Test Method for Pull-Of Strength of Coatings Using Portable Adhesion Testers, provides a method and describes the apparatus for conducting such tests. The successful mock-up then sets a standard to be met for the remainder of the project. An unsuccessful mock-up reveals problems and helps identify corrective actions.

Conclusion

Along with the above mentioned keys to successfully coating above-grade concrete walls with high-performance, acrylic-textured coatings, one must never underestimate the importance of sound design details—overhangs, copings, flashings, drips—for shedding water and preventing it from entering into walls behind the coating. The combination of good details and clear, concise, complete, and correct specifications increases the service life of the coating, enhances building appearance, and reduces maintenance.

Fig. Application of high performance coating in progress