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Journal

Best Practices for Architectural Coatings

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Architectural paints and coatings have a long history of application across a wide range of construction and surface types, yet they are among the most misunderstood and misused of building materials. Originating in European traditions, architectural painting in North America experienced a dramatic shift in the mid-nineteenth century, when mass production and the growth of the petrochemical industry changed both the products themselves and the specialized trade that had developed for their preparation and application.

The coating on this decorative terra cotta element protects the surface from exposure.

The development of synthetic resins, artificial pigments, and other technological advances has improved the stability, ease of application, and availability of paints and coatings to the degree that it can seem unnecessary to employ skilled labor to apply such failsafe products; yet, understanding these products in terms of their properties and behavior seems to demand an advanced degree in chemical sciences, with the array of components so vast and their names so technical and esoteric.

To demystify the field of architectural coatings, and, by so doing, improve outcomes in the removal, selection, and application of paints, waterproofing coatings, protective products, and other surface treatments is the goal of this introductory guide. In such a brief space, this article can only touch on some of the diverse products and considerations in the broad array of available coatings. However, given the number of buildings that are irreparably damaged by the uninformed and indiscriminate use of coatings, it is critical to understand the basic composition of coatings, their appropriate uses, and considerations for their specification, application, restoration, and replacement.

Composition

In general, paints are comprised of two elements: the pigment and the vehicle. The former imparts color, texture, and opacity, while the latter provides fluidity, adhesion, permeability, and durability.

Pigment

Finely divided coloring materials, pigments are suspended as discrete particles in the vehicle. Traditional inorganic pigments include clay earths and crushed minerals, the color palette of which has been refined and expanded over the years with the addition of manufactured artificial pigments. Organic pigments, traditionally derived from animal and vegetable

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sources, also include coal-tar synthetic colorants.

In addition to color and opacity, pigments impart other properties to paint, including light-fastness, pH sensitivity, dispersion, consistency, and drying effect. Understanding which pigments possess which properties, and capitalizing on these effects, can improve the appearance and durability of the paint application.

Vehicle

The liquid component of the paint system, the vehicle (also known as the *medium*) carries the pigment and imparts the cohesive and adhesive film-forming properties of the coating. Other properties, including elasticity, consistency, plasticity, viscosity, and reversibility, among many others, may also be attributed to the vehicle. The type of substrate determines the appropriate vehicle.

The vehicle, in turn, is often made up of two components: the *binder* and the *solvent*. Most binders are classified as aqueous (water-based) or non-aqueous and are derived from natural animal, plant, and mineral sources or, more recently, from synthetic resins such as alkyds, vinyls, epoxies, and urethanes.

Solvents—the volatile portion of the vehicle—aid in the initial application of the product and later evaporate during film formation. In recent years, solvents containing volatile organic compounds (VOCs) have been largely phased out for interior applications in favor of water-based products, as inhalation of vapors has been shown to cause health problems.

Additives

A third, and far smaller, class of component in coatings are termed *additives*, and these are used in small proportion to impart desirable properties to the coating. Additives can act as freeze-thaw stabilizers, biocides, preservatives, pigment suspension aids, accelerators, emulsifiers, de-foamers, and wetting or drying agents.

Coating replacement can restore historic buildings to their original appearance.

Assessing Failure and Deterioration

Over time, coatings will require replacement. Since the lifespan of paints and coatings depends largely on the condition of the substrate to which they have been applied, coating failure may be symptomatic of larger building distress. Before replacing peeling paint or a failed coating with another coat, it is advisable to investigate the condition(s) that may have led the coating to deteriorate.

If the paint film or coating failure is not attributable to other building conditions, potential causes for premature breakdown may be related to inferior paint composition, poor surface preparation or application techniques, incompatibility of different paint layers, and/or exposure due to climate or proximity to water-shedding elements. Higher-grade coatings tend to have longer life expectancies, but the lifespan of any coating can be cut short by environmental conditions or faulty workmanship.

Common conditions and deterioration mechanisms include:

Peeling and blistering: loss of adhesion between coating layers (cohesive failure) or at the interface with the building element (adhesive failure), typically caused by inadequate surface preparation, incompatibility between coating layers, trapped water vapor, extreme temperatures, or too rapid drying and entrapment of the volatile vehicle.

Wrinkling: deformation of the coating due to application on a cold surface, coating layers applied too thickly, or coatings applied before the previous coat has dried.

Crazing, checking, or microcracking: fine patterns of cracking in brittle or excessively thick coatings that cannot expand or contract to accommodate dimensional changes in the substrate; often the result of low-quality paint, insufficient drying time between coats, trapped moisture, or long-term ultraviolet (UV) exposure.

Alligatoring: deep, open cracks that resemble an alligator's hide, which can result if crazed or cracked coatings are not replaced, or if many built-up paint layers form a thick coating that is exposed to years and years of UV radiation.

Chalking: photochemical breakdown of the binder, usually due to UV exposure, leading to a powdery surface.

Discoloration: stains and changes in color that may result from a number of factors, such as biological growth, environmental conditions including pH levels and light exposure, and oxidation.

Restoration

Particularly for historic structures, restoration typically includes research and testing to identify the original building appearance, or that at a significant date. In addition to examination of historical records and period photographs, the investigation may include collection and laboratory analysis of paint samples to assess the structure, composition, and color of what can often be many layers of paint.

If the intention of restoration is to revert to an uncoated surface and expose the substrate, it's important to consider the reason the coating was initially applied. If the coating was used to disguise poorly executed repairs or cover deteriorating masonry, it will likely be necessary to restore the integrity and soundness of the substrate prior to reversion to an uncoated surface or reapplication of the coating. If paint was applied to conceal unmatched repairs or mottled surfaces, coating removal may yield an unsatisfactory appearance. To determine underlying conditions, test panel removals are recommended.

In the case of historic or older structures for which paint is part of the building character, the properties and appearance of the original coatings should be reproduced to preserve the architectural aesthetic. Removal of older, built-up paint layers is necessary to achieve a sound substrate for recoating.

Removal

The four basic approaches to coating removal involve heat, chemical strippers, poulticing, or mechanical removal by means of abrasion.

Heat removal will only work with paints that soften in response to higher temperatures, and care must be taken to avoid scorching the underlying surface or igniting flammable materials within the wall assembly.

Chemical stripping agents are toxic and require proper containment and disposal, and they can damage surfaces, depositing harmful residues on porous materials.

Poultice application consists of absorbent material mixed with solvent to form a paste, which can improve the effectiveness of chemical removal; however, by increasing contact time, poulticing may also deposit chemical residues or stains that are difficult to remove.

Abrasive and mechanical techniques can be effective, but they may cause irreparable damage if the pressure is too high, the aggregate too abrasive, or the grinding/sanding too aggressive, such that cleaning abrades the substrate.

The use of chemical cleaning will likely require testing on a small scale before undertaking large-scale removals. Neutralizing washes and water rinses may be required. To avoid penalties, such as fines or stop-work orders, a plan should be made for the environmentally safe disposal of cleaning agents and rinsing effluent, as dictated by the Environmental Protection Agency (EPA) or local regulatory authority. Depending on the age of the structure, testing for lead-based paint may be required prior to removal, with appropriate procedures for abatement.

With recent legal restrictions on the use of VOCs, alternative detergent and enzyme products have been developed to replace these toxic and high-odor solvents. As people have grown accustomed to low- or no-VOC products, foul odors of any kind have become unacceptable to building occupants, even if the product is not technically harmful.

As an example of the potential impact of paint removal on project progress, the stripping chemical employed by the contractor at one recent project produced such a strong odor that work was stopped and the building emptied. To avoid unexpected delays and disruptions, a mockup should guide coating removal planning. Testing can confirm suitability, particularly if removal is to be complete while the building is occupied.

Conservation

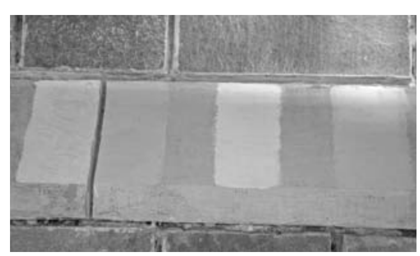
Where preservation or replication of existing coatings is required, historical records and laboratory analysis of paint samples inform visual color matching. Should the toxicity or instability of the original coatings prevent their use in restoration, historic and landmark requirements may be satisfied with modern substitutes designed for such applications. Although the right hue is essential, gloss, texture, transparency, and other qualities will affect the color match.

Materials with high stability and reversibility are best suited for conservation. Keep in mind that many coatings, once applied, may not be removed without damaging the substrate.

Coating Selection

The *substrate*, or building material to which the coating will be applied, will determine the type of coating best suited to the situation, as well as the surface preparation necessary for durability and long-term performance.

Wood window coating deterioration.



Field testing of coating samples for best match to original color and gloss.

Environmental Considerations for Coating Specification

With the rapid growth of the petrochemical industry after World War II, most standard paints and coatings began to incorporate materials derived from petroleum, which, when refined from crude oil, contains hydrogen and carbon molecules that form the long-chain macromolecules in plastics and synthetic resins. A non-renewable resource, petroleum contributes to air and water pollution as part of the extraction and refining process. As an alternative, paints and coatings manufactured from plant sources and minerals are available. Federal procurement requirements for government projects encourage the specification of biobased paints and coatings, as opposed to those from non-renewable resources like petroleum.

Low-toxicity, low-VOC (volatile organic compound) alternatives exist for most conventional paint and coating products. However, there is no standard regulatory definition for "low-VOC" or "low-toxicity," and products labeled as such can still contain harmful or odorous ingredients, including ammonia, formaldehyde, odor-masking agents, and fungicides and bactericides. Water-based paints are usually safer to handle than those with organic solvents, and they can be cleaned up with water, reducing health risks to workers and occupants and minimizing (or eliminating) hazardous waste.

While the performance of biobased and low-VOC products has improved over the past several years, design professionals and building owners should consider product performance data and test results when selecting any type of paint or coating, including newer environmentally conscious products. The right coating combines ecological sensitivity with performance characteristics that are suitable for the substrate, building, and situation. ■

Of primary consideration when selecting a coating is whether the product will be applied on the building interior or exterior. The coating requirements for interior window frame and sash components, for instance, are likely to be different from the coating requirements for exterior exposure. For interior applications, VOCs and odor will be the principal environmental considerations.

For coatings that will be used on the building exterior, considerations include weather conditions, such as acid rain, wind-driven rain, ice, standing water, and freeze-thaw cycling. Some coatings can only be exposed to UV light for a limited period of time, as established by the manufacturer and driven by project warranty requirements. The manufacturer also typically stipulates application within specific ranges of temperature and humidity.

Cost may also be a consideration when selecting a coating. Higher-performance coating systems cost more, and the determining factor in choosing a product is often price rather than life expectancy. In calculating a coating's true price tag, though, owners and managers would do well to consider not just installation and material cost alone, but also the life-cycle cost. Since much of the expense of a painting or coating project is in labor, cutting costs by opting for a cheaper paint with a shorter lifespan may actually increase overall life-cycle expenditures.

It is usually advisable to select a complete coating system from a single manufacturer, to avoid incompatibility between coats. If different brands of primers, paints, or finishing coats are combined, the design professional should evaluate the proposed system with the manufacturers to confirm compatibility and to verify that the combination will not adversely affect the warranty.

Water-Repellent and Waterproof Coatings

Intended to prevent liquid water from penetrating the surface while allowing water vapor to escape to the exterior, *water-repellent coatings* are transparent and intended to be invisible, although they may darken the substrate or impart a sheen/gloss. In contrast, *waterproof coatings* create a barrier that is impermeable to both liquid water and water vapor. Often opaque, waterproof coatings include bituminous, cementitious, and some elastomeric products.

Early water-repellent coatings were typically acrylic or silicone resins in organic solvents, which worked by forming a film on the surface of the building material. Newer water-based coatings are composed of modified siloxanes, silanes, alkoysilanes, or metallic stearates; these water-repellents penetrate into wood, concrete, or masonry and are almost imperceptible if properly applied. However, some formulations may cause undesirable shine or darkening of the substrate. A mockup of the coating application should be performed to confirm that the appearance of the coated material is acceptable.

Considerations for the use of water-repellent coatings include trapped moisture and related water damage, which can occur when water vapor condenses within the substrate, and the liquid water is unable to escape through the coating. Moreover, once a surface has been coated, it is not possible to return to an uncoated state—even if the coating fails. Coatings typically require periodic reapplication, and so a water-repellent coating creates an ongoing maintenance need for the life of the building. Compared with the expense of patch repairs or material replacement, coating to protect a fragile or high-exposure substrate can sometimes be a cost-effective repair.

Water-repellent coatings should be applied to clean and dry surfaces. If applied to already deteriorated surfaces, water-repellent coatings may exacerbate the damage by trapping moisture, accelerating deterioration and even pulling off the face of the building element should the coating fail. Water-repellent coatings are not consolidants and cannot be used to strengthen deteriorating brick, concrete, or stone. If the facade is kept in good repair, water-repellent coatings are usually not necessary or recommended.

In some cases, water-repellents may be considered in selected areas or for specific substrates. A design professional should first evaluate the envelope water-tightness and should determine whether, despite proper rehabilitation measures, moisture is penetrating through exterior wall components. If water-repellent treatment is determined to be appropriate, it is best to treat only isolated problem materials or weaker areas, such as those exposed to weather extremes, rather than the entire building.

Unlike water-repellent coatings, waterproof coatings do not permit migration of water in any state—whether liquid or vapor—either into or out of the wall. If water enters the wall via a roof leak, through the building interior, or by means of capillary migration (rising damp) from the ground, it will be unable to escape if a waterproof coating has been applied. Trapped water can and will cause extensive damage, particularly if freeze-thaw cycling exceeds the tensile strength of the material and causes the substrate to break apart.

Waterproof coatings are often used in isolated cases for below-grade applications, but it is generally inadvisable to use them above ground for most types of buildings, particularly historic structures.

Anti-Microbial Coatings

Coating products that claim to prevent dirt accumulation or biological growth and so reduce maintenance demands may be effective; however, in some cases a coated surface may attract more dirt or encourage more biological growth than an uncoated one. Routine cleaning with gentle methods appropriate to the building material may prove just as effective, with the added benefit of avoiding the added maintenance and inadvertent ramifications that accompany coatings.

Getting It Right: The Details

Each participant in the design, production, and application of a coating has a role in determining the long-term success of the installation. Taking into consideration the type of substrate to receive the coating, the condition of building materials, environmental factors, product performance data, color and gloss, permeability, and other criteria, the design professional selects the coating and specifies any test methods, mockup standards, and application requirements that might be relevant.

The contractor is responsible for submittals to be reviewed by the architect for all products and installation details. The manufacturer, in turn, verifies that the proposed installation will meet warranty requirements. Once drawings, specifications, and submittals have been approved, the design professional should conduct site visits to evaluate preparation and mockups, address unanticipated field conditions, and verify that application meets the design criteria.

Before a coating is applied, the substrate must be restored to a smooth, sound condition.

Substrate Preparation

The smoothness and soundness of the surface is critical to the long-term durability of a coating. Typically materials with rough and irregular surfaces are not ideal for direct coating applications. Coatings are not designed to bridge gaps, such as bug holes, small fissures, or areas where mortar joints are no longer fully packed; while a coating may appear to cover a crack, once it dries, the crack may telegraph through.

Coatings differ in the degree of substrate unevenness they can tolerate in order to perform as designed. A coating cannot be expected to correct deficiencies such as an unstable or crumbling surface. Removal of unsound material is required. To create a smooth, sound surface for coating application, all friable debris should be removed and surface repairs made prior to applying the coating. This includes removal of existing coatings that would prevent adhesion of the new coating to the surface.

Addition of a *parging coat,* a thin layer of cementitious material, to an uneven surface can create a smooth outer layer that is suitable to receive a coating. Depending upon the composition of the parging coat, a minimum curing time will be required by the manufacturer before a coating may be applied on top. Design professionals and owners should note that the curing time for different types of materials, and the effect on project schedule, can vary substantially. Cementitious compounds can take days to cure, whereas polymer-modified mortars can effectively cure and be ready to coat in hours.

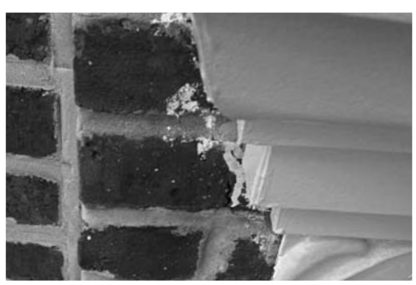
Protection of the substrate may be necessary to provide adequate conditions for curing. In order to facilitate proper adhesion and prevent water from becoming trapped behind the coating, the moisture content of the substrate must not exceed the maximum allowable level indicated by the coating manufacturer.

The Society for Protective Coatings (SSPC) has prepared standards for surface preparation tailored for metals and concrete, while the National Park Service offers guidelines for historic masonry. Other resources, including the Sealant, Waterproofing, and Restoration Institute (SWRI), Association for Preservation Technology (APT), American Society for Testing and Materials (ASTM) and other industry groups provide further information on surface preparation for coating application.

Coating Application

Coating removal products are not the only consideration for odor and impact on occupants; coatings also can have strong fumes, and application should be tested during low-occupancy hours, such as evenings and weekends. Adhesion testing, by means of peel tests and other methods, may be used to evaluate and confirm the bond between coating and substrate, as well as ease of removal and reapplication.

Removal of a failed coating.



Failure to mask adjacent surfaces during coating application can leave indelible marks.

Once testing has been completed and the substrate prepared, the coating should be applied in overlapping segments, incorporating reinforcement, such as fiber mesh, as appropriate. Coating thickness, typically measured in *mils of dft* (dry film thickness), should comply with manufacturer requirements and be verified in the field. Manufacturers often supply measurement tools for this purpose. Too thin, and the coating will provide inadequate and/or uneven coverage; too thick, and the coating is unlikely to fully cure and may be vulnerable to tears and gouges. Additionally, if not fully cured, the coating may fail to adhere completely to the substrate, leading to peeling, blistering, and other manifestations of premature breakdown.

At termination points, the design professional should provide design details for coating finishing, such as feathering onto adjacent surfaces or application of protective masking on surrounding finishes to shield against accidental—and potentially irreversible—drips or splashes.

Once application is complete, the area should be protected during curing to provide favorable ambient conditions and create an atmosphere conducive to thorough drying and optimum adhesion. Project sequencing should aim to protect freshly coated areas from adjacent dust-producing operations.

A Pragmatic Approach

Unless the cleaning and removal of existing coatings and the specification and application of new coatings is guided by a knowledge of material properties and appropriate techniques, permanent damage to the building may be the unintended result. Before applying a water-repellent

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representative projects

Architectural Coatings

Architectural coatings is a broad term covering an array of liquid-applied materials, ranging from traditional linseed oil-based paints to protective mineral silicate coatings to the penetrating sealers and traffic coatings used for parking garages. At Hoffmann Architects, our specialized expertise in the building envelope has afforded the opportunity to work with diverse coating types and applications.

Our architects and engineers investigate existing conditions, direct testing, research appropriate products, evaluate mockups, and verify preparation and application. Our wide-ranging experience with coatings includes:

Georgetown University
Former Jesuit Residence
Washington, District of Columbia
Exterior Restoration, including Recoating Wood Windows and Metal Railings

Bushnell Tower
Hartford, Connecticut
Concrete Rehabilitation with Mineral Silicate Coating Application

Saint Thomas Seminary in Bloomfield, Connecticut. *Bell Tower Facade Rehabilitation with Limestone Coating Replacement.*

United States Capitol
Washington, District of Columbia
Cast Iron Dome Restoration, including Coating Evaluation, Removal, and Reapplication

Seneca Niagara Resort & Casino
Niagara Falls, New York
Parking Garage Rehabilitation, Traffic Coating Application, and Maintenance Program

Wellesley College
Tower Court Residence Halls
Wellesley, Massachusetts
Building Envelope Restoration, including Mineral Silicate and Water-Repellent Coating Applications

37 East 12th Street Townhouse
New York, New York
Facade Rehabilitation, including Terra Cotta and Steel Cornice Coating Replacements

University Towers, 100 York Street
New Haven, Connecticut
Building Envelope Rehabilitation, including Balcony Coating Replacements

Greenwich Hospital, Prescott House
Greenwich, Connecticut
Facade Rehabilitation with Mineral Silicate Coating Replacement

The George Washington University, Square 77
Washington, District of Columbia
Facade Renovation Consultation, including Coating of Galvanized Steel Cornices

The Argonaut Building, 224 West 57th Street in New York, New York. *Terra Cotta Restoration and Coating Replacement.*

Scholastic, Inc. Headquarters
New York, New York
Cast Iron Facade Restoration, including Historic Paint Removal and Replacement

New Haven Courthouse
New Haven, Connecticut
Exterior Restoration, including Coating on Exterior Plaster Soffits

Columbia University
401 West 118th Street Apartments
New York, New York
Galvanized Steel Cornice Replacement, including Fluoropolymer Resin Coating

Middlesex Hospital
Middletown, Connecticut
Parking Garage Rehabilitation and Traffic Coating Application

48 Wall Street
New York, New York
Cupola Restoration, including Reinforced Elastomeric Coating Application

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(continued from page 6)

Restoration and recoating of this cast iron element required off-site conservation.

or waterproof coating, underlying problems that could be the cause of water infiltration should be addressed, and serious consideration given to whether the coating is necessary. For historic restoration, including buildings of the Modern era, the composition and appearance of the original paint should be closely replicated to protect the period character of the structure.

In all cases, coating selection should be guided by a long-term view of cost implications, rather than an up-front cost comparison of available products. The expense of rehabilitating an ill-conceived or poorly executed coating project can far outweigh the cost of appropriately specified, designed, and applied paints and coatings that are suitable for the substrate, condition, and location. Moreover, once a coating has been applied, it must be maintained, so the long-term cost of cleaning, upkeep, and eventual re-coating must be taken into consideration.

With a long history in building construction, paints and coatings are a vital and often little-considered element of the building envelope. Through thoughtful planning, research, and design, the prudent building owner or manager can enjoy the protective and aesthetic benefits that the judicious use of coatings can impart to the building exterior. ■

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