EXTERIOR WALL COATINGS FOR CONCRETE AND MASONRY

BY MICHAEL P. EDISON

Specifiers and users of exterior wall coatings face a daunting array of product choices. For formulators of these coatings, the alternatives may be even more overwhelming, as they must choose from thousands of combinations of available raw materials and chemical intermediates.

The first thing essential to making appropriate coating selections is a clear definition of application and performance objectives. Is the purpose of the coating primarily decorative, or are there specific waterproofing objectives as well? Are there particular conditions that will affect application, such as high or low temperatures, a site prone to high winds or moisture, or a congested location with a high potential for collateral damage? Does difficulty of access for eventual recoating mandate a selection with higher initial cost but longer service life? Is the site historic and subject to preservation guidelines in addition to the general performance requirements? Once these and other similar questions have been answered, the process of sorting through the various coating options can begin.

WATERBORNE VERSUS SOLVENT-BORNE

After decades of concerted effort and development work by raw material and coating manufacturers, waterborne coatings have evolved to a point where they perform as well as or better than solvent-borne alternatives and will be the clear choice in most applications. Waterborne coatings generally offer lower odor and toxicity, volatile organic compound (VOC) compliance, ease of cleanup, and reduced fire hazard in storage. They also tend to be more tolerant of residual dampness in substrates at the time of application—a condition common to concrete and masonry wall systems.

Most waterborne exterior coatings, however, incorporate volatile organic solvents, which aid in latex coalescence, film formation, and controlling drying rates. Product VOC content can be used as a general yardstick for comparing solvent levels in otherwise similar products and great progress has been made in recent years in terms of VOC reduction.

In some applications with special requirements, solvent-borne coatings may be the best alternative. This is particularly true in cases requiring extremely fast drying time or application at very low temperatures.

CHOOSING A BINDER

Coating ingredients can be categorized into several basic groups, and selections made by formulators in each of these categories will determine the specific application and performance properties of the coating:

A. Binders;
B. Pigments and Extenders;
C. Solvents; and
D. Additives.

Of these categories, the binder has the most profound impact on coating properties and performance. It is the binder's function to form a film and hold together the other ingredients, develop good adhesion to the substrate, and withstand the rigors of exterior exposure.

A wide variety of binders are commercially available and in use for exterior masonry wall coatings today. Binders can generally be divided into two groups:

- **Organic** binders include the full range of synthetic resins commonly used in paints, including acrylics, silicones, polyurethanes, epoxies, polyesters, and polyvinyl acetates. Some natural binder materials are also organic, including oils and casein, although these are generally considered unsuitable for concrete and masonry applications due to poor resistance to cement alkalinity.
- **Inorganic** binders include lime, portland cement, and solutions of silicate compounds. Their matrixes are very different from the organic binders in both chemistry and structure, resulting in very different performance properties.

ACRYLIC COATINGS

Of the organic binders, acrylic latex polymers and copolymers have the most favorable balance of properties and cost benefit for general exterior wall coating applications. This accounts for their dominance of the worldwide exterior coating market.

Epoxies and polyesters tend to produce films with very low moisture vapor permeability. This can lead to moisture entrapment behind the paint film and eventual damage to the concrete or masonry substrate. They are also susceptible to degradation when exposed to ultraviolet (UV) radiation in sunlight, as are binders based on polystyrene and aromatic polyurethanes. In these compounds, the discoloration that occurs in exterior exposures is symptomatic of a breakdown in the binder's chemical structure and performance. UV stabilization technology has been used effectively in epoxy and polyester deck coatings.

Aliphatic polyurethane emulsions provide tough, flexible films with exceptional exterior durability and are frequently used in applications such as anti-graffiti coatings, where a high degree of chemical resistance is required. They can also provide durable high-gloss finishes that simulate brick and terra-cotta glazes. For general wall coating applications, however, they are relatively costly, although their long service life potential may justify their higher initial expense for applications where cost of access for eventual recoating is a more significant factor than material cost.

Acrylic binders may be characterized as either "pure" acrylics or as copolymers with other functional groups. Pure acrylics, often marketed as "100% acrylics," incorporate one or more acrylic functional groups.

Acrylic copolymers, combining acrylic with other functional groups such as polystyrene, may benefit from the positive characteristics of those groups, but are also compromised by their respective limitations. For example, benefits such as higher chemical resistance, water resistance, and adhesion are obtained with styrenated acrylics, but they also have a greater tendency to discolor and chalk when exposed to sunlight.

Pure acrylics are an extremely versatile group of resins. Although higher in cost than some alternatives, they are valued for their good color retention and exterior durability. Different acrylic functional groups produce polymers with very different properties. Methyl methacrylate, for example, is an extremely hard polymer, used in bulletproof glazing. Ethyl acrylate is a relatively soft polymer, such as may be used in acrylic caulks. By combining different acrylic groups, copolymers with the desired balance of hardness, adhesion, and water resistance can be obtained.

Harder acrylic binders are the bases for durable, dirt-resistant decorative exterior wall coatings. On the opposite end of the scale, elastomeric acrylic coatings have the capacity to elongate and recover when exposed to cyclical stress, as may be encountered when bridging small working cracks in concrete and masonry. Figure 1 shows an historic concrete bridge coated with an acrylic elastomeric coating. Softer acrylic coatings may also tend to induce less stress in older coatings over which they are applied, prolonging service life for applications on previously painted surfaces.

ELASTOMERIC ACRYLIC COATINGS

Although many acrylic coatings are marketed as "elastomeric," not all of them display the properties of a true elastomer. Many acrylic latex coatings exhibit significant elongation at moderate temperatures.

Fig. 1: An historic concrete bridge on the Merritt Parkway in Connecticut coated with an acrylic elastomeric coating custom-matched to the original concrete color. The coating was applied over residual graffiti and previous coatings after their substantial removal

True elastomers will not only elongate but also recover substantially after the stress is removed. They will remain elastomeric at low temperatures, including the full range of normal exterior service temperatures. Many acrylic coatings become brittle at temperatures below 40 to 50°F (4 to 10°C), while true elastomers remain flexible at or below 0°F (–18°C). True elastomers also remain permanently flexible, substantially retaining their ability to elongate and recover even after 10 to 20 years of exterior exposure. Many acrylic latex coatings are rendered flexible by the incorporation of plasticizers, which soften otherwise hard polymers. These plasticizers eventually wash out or break down, leaving an embrittled coating with increased tendency to crack, flake, or peel.

Disadvantages of acrylic elastomers include a higher tendency to collect dirt over time and a general tendency to reduce moisture vapor transmission rates through coated surfaces. While waterborne acrylic coatings can generally be classified as "breathable," or able to transmit moisture vapor, many will significantly cut vapor transmission rates compared with uncoated surfaces. Reductions in vapor transmission rates to the order of 50 to 75% are not atypical. Whereas elastomeric coatings generally require application of thicker films to develop the capacity to stretch across working cracks without tearing, they tend to reduce vapor transmission rates even more significantly than coatings applied at lower film thickness. A number of manufacturers, however, have developed elastomeric acrylic coatings with fairly high vapor permeability.

In cases involving relatively weathertight building envelopes with internal moisture barriers, acrylic wall coatings will generally provide adequate permeability for applications on concrete and masonry wall systems. However, eventual recoating of surfaces painted with organic wall coatings will result in further reductions in vapor transmission rates, and in the course of one or more reapplications over time, vapor transmission may become insufficient. At that point, coating removal becomes necessary to avoid damage to the substrate. The removal process itself can be damaging and is relatively costly.

More recently, silicone elastomeric coatings have become available and offer a good balance of permeability and durability as well as the advantage of compatibility with silicone-based sealants. Manufacturers caution users to expect the need for periodic cleaning and represent these materials as performance coatings, rather than aesthetic. Clear aliphatic polyurethane elastomerics have become available as well, and they offer a good balance of aesthetics, durability, and permeability. Figure 2 shows the application of an aliphatic polyurethane coating to terra-cotta glaze repairs.

While many commercial and industrial buildings tend to have relatively short design service lives in terms of economic write-off, most buildings will remain in service for as long as they are practically maintainable. Buildings with historic value have an additional mandate to be preserved in a sustainable manner. As a result, greater attention has recently been focused on the long-term costs and impact of various wall coating alternatives. As these full life-cycle implications are given greater weight, the use of high-permeability, durable, inorganic coating systems has increased dramatically.

INORGANIC COATINGS

The use of limewash as a masonry coating was practiced in ancient cities thousands of years ago. It is still in use to some extent today. Lime (calcium hydroxide) applied to exterior masonry walls reacts with atmospheric carbon dioxide to form a crust of calcium carbonate.

The disadvantages of limewash include relatively short service life and high labor costs for application. While high in permeability, water resistance is limited and it is not uncommon for damage to become evident in as little as 1 year in severe weather climates, or for reapplication to be required on a 2- to 3-year cycle. Durability can be improved by incorporating natural cement or natural hydraulic lime. Tendencies toward streaking and other aesthetic anomalies may not meet the high expectations of owners and specifiers.

In the past century, portland cement has been used to form a more durable inorganic coating. Properly formulated, applied, and cured portland cement-based coatings can provide higher durability and water resistance than limewash, although they are more rigid and somewhat lower in permeability. Application costs are generally higher than for acrylic latex paints, and results are less consistent in terms of film thickness, texture, and color uniformity. Long-term adhesive performance has generally been worse than for acrylic coatings, and acrylic latex admixtures have sometimes been substituted for all or part of the mixing water to improve adhesion and reduce or eliminate wet-curing requirements. Limited use of latex modi-

Fig. 2: Worker applies custom-matched aliphatic polyurethane coating to terra-cotta glaze repairs at the California State Library in Sacramento, CA

fiers in limewash has indicated the potential for similar improvements.

While latex-modified portland cement paint compositions can be very useful in situations where the development of texture and higher build are desired, these characteristics are undesirable in many cases. High build and texture can be positive in situations where there has been erosion of original surfaces, or where repairs are a poor match to original substrates in texture. But where the objective is decoration and protection without obscuring surface detail or altering surface profile, portland cement-based coatings are less suitable than other alternatives.

Masonry coatings based on potassium silicate have been in use in Europe for more than a century. Potassium silicate has the capacity to react with a variety of mineral and metallic building substrates to form stable, permeable structures. Permeability close to 100% is reported for some of these coatings. Figure 3 shows a potassium silicate mineral coating installed on new concrete of a bridge replacement span.

More recently, lithium silicates have been employed as inorganic coating binders, either solely or in combination with potassium silicates. The inorganic structure of these binders provides several additional benefits. These include fire resistance, resistance to mold and other biological growth and, in some cases, superior resistance to long-term moisture exposure.

Polymers typically used in organic wall coatings contribute to flame spread and smoke generation in cases of fire. They also typically contain ingredients that are biodegradable, providing a nutrient source for mold and mildew. While many coatings contain biocides to protect the coatings from degradation in the container and some contain additives designed to hinder in-place biological attack, they cannot provide the certainty and longevity of resistance to biological attack offered by inorganic coatings formulated without biodegradable ingredients altogether.

Potassium and lithium silicate coatings usually incorporate water-repellent ingredients which enhance protection from water infiltration without hindering moisture vapor transmission—an effective combination for a wide range of masonry and concrete applications. Formulations are available in several consistencies from heavy paints to penetrating stains.

There are some important limitations, however, to the use of silicate coatings. While silicates can dry and form a film, the full development of their most important performance properties can only occur if they react with the substrate. This reaction cannot occur if previous organic coatings or residues of organic coatings remain in place. Some residual water repellents may also hinder reaction of the silicate with the substrate. For this reason, silicates are not typically used on buildings previously painted with organic coatings unless complete removal of those coatings is assured. Pretesting of adhesion and compatibility through mockups is indispensable prior to large-scale treatment.

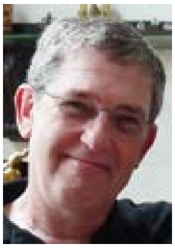
Fig. 3: A replacement span between two remaining historic concrete piers on another Merritt Parkway bridge coated with a color-matched potassium silicate mineral coating

Silicates are relatively rigid coatings. While they maintain good compatibility with mineral substrates due to similar coefficients of thermal expansion, they cannot bridge working cracks and cannot be applied over sealants or other synthetic materials. They can also be difficult to remove and are irreversible, which is considered a negative for some historic preservation applications.

CONCLUSIONS

Concrete and masonry restoration, decoration, and protection projects have individual objectives, conditions, service exposures, and economic constraints. To meet the requirements of the full spectrum of project situations, a diverse range of materials and properties is required.

Although the challenge of selecting among the myriad available concrete and masonry coating products can be daunting, there has never been a better range of alternative materials and technologies available than those that are in use today.



__Michael P. Edison__ is the Founder and President of Edison Coatings, Inc., in Plainville, CT. For over 30 years, Edison Coatings has been developing and manufacturing specialty materials for repair, protection, and decoration of masonry and concrete buildings and structures. Edison holds a Bachelor of Science degree in chemical engineering and a master's degree in business administration. His professional career spans more than 40 years and includes work in product development, process development, construction management, and technical services.