

# ReBuild

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A Quarterly Newsletter

## Reader's Interaction Solicited

Our Newsletter is focused on good concreting practices, waterproofing, repair, rehabilitation and maintenance of concrete structures and buildings. Any reader, who wishes to contribute his or her experience or achievements in this field to our Newsletter for wider dissemination, may send the details to:

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**DR. FIXIT INSTITUTE**

OF STRUCTURAL PROTECTION & REHABILITATION

**Protective Coatings**

This issue of our Newsletter is devoted to coating materials, so important for protection and durability of any substrate. Coatings in general are closely interrelated with paints, inks and adhesives and are generally based on the same raw material components such as resins, solvents, pigments and additives.

Resins include binders, polymers, elastomers and are known by their chemical names such as acrylic, alkyd, nitrocellulose, etc. Their job is to hold the coating together and adhere it to the substrate. Solvents-organic and water - permit the coating to be applied to the substrate. Pigments come in many types and they are there for aesthetic purposes, resistance properties or reinforcing properties. Additives are materials added in small quantities to modify the overall properties to meet a specification.

Since their introduction decades ago, acrylic polymers have gained a strong foothold in the coatings as a result of their improved flexibility and adhesion compared to polyvinyl acetate emulsions, phenolics and styrene-butadiene latex combined with their moderate cost. In addition, their significantly improved outdoor durability, including resistance to ultraviolet degradation, has mandated their use in several applications. In many respects, the name "acrylic" has become synonymous with high performance in polymer coating systems.

However, in the recent times it seems there is an occurrence of polyurea revolution. Polyureas are closely related to polyurethanes. Both Polyureas and Polyurethanes are based on a two-component system with one component being an isocyanate material. The second component for polyureas is a polyether polyamine, whereas polyurethanes need a polyether polyol. Polyurethanes require a catalyst to speed up the reaction time of the components, whereas, Polyureas do not. Thus, polyureas are able to cure at any temperature and also in the presence of moisture-conditions that are not very conducive for polyurethanes. Further, the fast curing ability of polyureas is inherent in their chemistry, which gives them several unique properties.

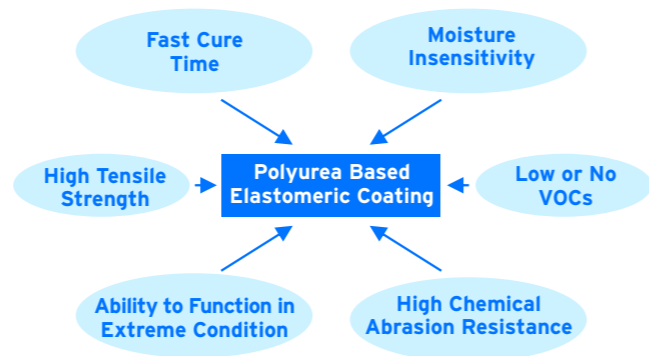
Polyurea coatings are sprayed through 1:1 ratio heated plural-component equipment. This equipment, depending on the model type, creates pressure of 7 to 20 MPa. Because of this as well as instantaneous gel time, polyureas can be built to any thickness in one coat. This is of particular importance on vertical and overhead surfaces to be coated. The polyurea surface can be walked on in 30 seconds for inspection. The main areas of performance are to resist rupture, water, chemicals and weather.

All in all, polyurea coatings are becoming the coating of choice. A wide variety of imaginative uses are developing as people gain experience with polyurea elastomeric systems.

Although I have mentioned about a limited member of coating materials, we should not forget that today there are more than 40 different coating materials in the market and a reselection of materials for applications, depending on customer performance and technological considerations. Hence, the selection of an appropriate coating system is a complicated task that demands technical knowledge, judgement and acumen.

In this issue we have attempted to bring to you a set of articles that will reinforce your efforts to do the material selection in a very rational manner. We shall look forward to receiving feedback from our readers and patrons.

**Features of Polyurea-based Elastomeric Coating**



**Coating Application Equipment**

<b>Non-spray Techniques</b>	Dip Coating
	Flow Coating
	Dip-sin Coating
	Roll Coating(direct and reverse)
<b>Spray Techniques</b>	Conventional Air Atomization
	Airless Atomization
	Air-Assisted Airless Atomization
	High Volume, Low Pressure Air-Atomizing Spray
	Flame Spray Coating
<b>Electrostatics</b>	Electrostatic Spray
	Rotary Atomization

**Exterior Wall Coatings for Concrete and Masonry**

by Michael P. Edison

(Extracted from Concrete Repair Bulletin January / February 2005)

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 among an almost unlimited number of combinations of the thousands of available raw materials and chemical intermediates.

A clear definition of application and performance objectives is the first essential in making appropriate coating selections. 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 re coating mandate a selection with higher initial cost but longer service life? Is the site historic and subject to the U.S. Secretary of the Interior's 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 options can begin.

**Waterborne or Solvent Borne?**

One of the most basic decisions is whether to limit selections to products in which water is the primary vehicle. Waterborne coatings generally offer significant advantages, including low odor and toxicity, VOC(Volatile Organic Compound) compliance, ease of clean-up, 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. After several decades of concerted effort and development work by raw materials and coatings manufacturers, waterborne coatings have evolved to a point where they generally perform as well or better than solvent-borne alternatives and will be the clear choice in most applications.

In some applications with special requirements, however, solvent borne coatings may still be the only viable alternative. This will be particularly true in cases requiring extremely fast drying or for applications at very low temperatures. It should also be noted that most waterborne coatings incorporate some level of organic solvents, which aid in latex coalescence, film formation and

in controlling drying rates. Product VOC content can be used as a general yardstick for comparing solvent levels in otherwise similar products.

**Choosing a Binder**

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

**Binders**-These are the materials that hold the coating together and adhere it to the wall.

**Pigments and Extenders**-These provide color, hiding of the substrate, bulk. And hardness, among other properties.

**Solvents**-These are carriers for the active ingredients, allowing them to spread evenly over the wall surface. They also control drying rate, which has an important influence on film formation, penetration, and adhesion.

**Additives**-There are a wide variety of additives used in wall coatings. These range in their functions from viscosity, leveling, and foam control to ultraviolet stabilization and antimicrobial protection.

Of these groups, 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 all of the other ingredients, as well as to develop good adhesion to the substrate and to withstand the rigors of exterior exposure.

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

- Organic binders include the full range of synthetic resins commonly used in latex paints, including acrylics, alkyds, polyurethanes, epoxies, polyesters, polyvinyl acetate, and polystyrene. Copolymers combining different acrylic groups are also widely used. As each group has its own typical range of performance characteristics, copolymers can often provide properties unavailable from a single, homogeneous polymer(homopolymers).Some natural binder materials are also organic, including oils and casein.
- 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.

## History of wall coating binders

Time line	Binder types	Uses
Prehistoric: 10,000 years ago	Blood, mud, sap, weeds, berries	Interior cave wall painting
Egyptians: 4,000 years ago	Distemper: casein, egg whites, milk, gums, starches	Interior decorative wall coatings
Romans: 2,000 years ago	Lime, whitewash, Roman cement (Pozzolana)	Interior/exterior wall coatings waterproof renders
Industrial era: 1870s	Drying oils, casein	First factory-produced, interior/exterior commercial paints
Late 19th/early 20th Centuries	Portland cement, silicates	Durable exterior masonry paints
World War II	Vinyl acetate, polyurethane, epoxy, silicone	Synthetic replacements for scarce natural ingredients
Post-war era: 1950s	Polyvinyl acetate, SBR latex, acrylic latex	Interior and exterior latex paints
1970s	Gloss acrylic latex	Replacement for oil based paints and enamels
1980s	High-performance waterborne acrylics, epoxies, silicones, polyurethanes	VOC compliant coatings
1980s/1990s	One-part potassium silicates	Durable masonry coatings

## Organic Coatings

While epoxies, polyurethanes, polyesters, and other binders have some specialized applications, the worldwide wall coatings market is heavily dominated by acrylic latex technology. By some estimates, as much as 85% of all the paint produced and sold worldwide is based on acrylic latex technology.

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.

While acrylic copolymers, with other functional groups such as polystyrene, may benefit from the positive

characteristics of those groups, such as higher chemical resistance, water resistance, and/or adhesion, they also tend to be diminished by the negative characteristics of those groups. Accordingly, styrene-acrylic copolymers have a greater tendency to discolor and/or chalk when exposed to sunlight. Vinyl acetate-acrylic copolymers offer lower costs than pure acrylic systems, but also suffer from the reduced water resistance typical of the vinyl acetates.

Pure acrylics are an extremely versatile group of resins. Although somewhat higher in cost than some of the 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, produces extremely hard polymers, such as those that may be used in bullet-proof glazing. Ethyl acrylate produces relatively soft polymers, such as may be used in acrylic caulks. By combining different acrylic groups, copolymers with the desired balance of hardness, adhesion, flexibility, and water resistance can be obtained.

## Elastomeric Acrylic Coatings

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. Softer acrylic coatings also tend to induce less stress in previously applied coatings over which they are applied, prolonging service life for applications on previously painted surfaces.

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

True elastomers will not only elongate, but will also recover substantially after the stress is removed. They will also remain elastomeric at low temperatures, including the full range of normal exterior service temperatures. Many acrylic latex coatings become brittle at temperatures below 4 to 10 °C, while true elastomers remain flexible at temperatures below -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. Low-cost acrylic latex coatings are rendered flexible by incorporation of plasticizers, which soften other-wise normally harder polymers. These plasticizers eventually wash out or break down, leaving behind 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 water-borne acrylic coatings can generally be classified as “breathable,” or able to transmit moisture vapor, most will significantly cut vapor transmission rates compared with uncoated surfaces. Reductions in vapor transmission rates on the order of 50 to 90% are typical. 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. Some manufacturers, however, have developed elastomeric acrylic coatings with relatively high vapor permeability. The most breathable acrylic elastomeric coatings exhibit vapor transmission characteristics which rival even some potassium silicate coatings, which are prized for their high permeability.

In cases involving relatively weather-tight building envelopes with internal moisture barriers, acrylic wall coatings will generally provide adequate permeability for applications on concrete and masonry wall systems. Eventual re coating of surfaces painted with organic wall coatings, however, 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, removal becomes necessary to avoid damage to the substrate. The removal process itself can be damaging and is relatively costly.

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. Often, these concerns can be addressed by selecting high-quality acrylic coatings with high-moisture vapor permeability and maximum long-term resistance to sunlight, microbiological attack, and moisture. Many mass-market latex paints, however, are designed first and foremost to be highly competitive in cost and formulation compromises of performance are commonly made to lower the cost of these products. Some manufacturers may also view paint systems that offer long-term durability as having a potential negative impact on resale business, as the more frequently buildings require repainting, the more paint they can hope to sell over time.

As a result of the limitations common to many commercial paints, 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

Lime wash was the first durable inorganic masonry coating, and its use extends back to ancient cities more than two thousand 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 lime wash include a 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 one year in severe weather climates, or for reapplication to be required on a 2- or 3-year cycle. Tendencies toward streaking and other aesthetic anomalies do not meet the high expectations of many 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 lime wash, although 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 poorer than for acrylic coatings, and acrylic latex admixtures have sometimes been substituted for all or part of the mixing water to improve cement paint adhesive performance and to reduce or eliminate wet-curing requirements.

While latex-modified portland cement paint compositions can be useful in situations where the development of texture and film build are desired, these characteristics are often undesirable. The addition of build and texture can be positive in situations where there has been significant erosion of original surfaces, or where previous repairs are a poor match to original substrates in terms of texture. But in cases where the objective is decoration and protection without obscuring surface detail or otherwise 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.

The inorganic structure 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 which are biodegradable, providing a nutrient source for algae, mold, and mildew. While most coatings contain biocides as additives to protect the coatings from degradation in the container, and some contain additives designed to hinder biological attack in situ, they cannot provide the certainty and longevity of resistance to biological attack offered by inorganic coatings formulated without biodegradable ingredients altogether.

Potassium silicate coatings frequently incorporate water repellent ingredients which offer 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 penetrating stains to heavy paints to textured coatings.

Resistance to long-term moisture exposure can be problematic to typical acrylic latex coatings. Although many are characterized as irreversible in terms of their film formation after application, acrylic latex polymers commonly soften and swell when exposed to continuous moisture. They are therefore generally not recommended for use under immersion or high constant moisture conditions. While use of some silicates carries a risk of their becoming redissolved under high moisture and immersion conditions, properly reacted and cured treatments can effectively become insoluble. This property is of the greatest value when treating concrete and masonry structures which will be exposed to extended or repeated periods of wetness. Such applications may include planters, fountains, retaining walls, coastal exposures, and open structures such as towers, monuments, and non-traffic surfaces in parking structures.

Some silicate coatings are fortified with acrylic latex. The latex facilitates application and improves the development of adhesion. At very low levels the acrylic additives can be beneficial, but if too much acrylic latex is added to the formula, the benefits and performance of the reactive silicate binder will suffer. These compromises typically manifest themselves in terms of reduced resistance to moisture, reduced solvent resistance, and lower bond strength. While reactive silicates will withstand continuous water immersion, silicates overextended with acrylic latex will soften and peel in relatively short order after immersion. Reactive silicates can also bond tenaciously to

smooth, hard, nonporous substrates such as glass, polished stone, and glazed brick or terracotta, whereas acrylic modified silicates may develop poorer bond to these substrates. Reactive silicates will be sufficiently insensitive to organic solvents as to allow removal of graffiti without dissolving the coating, but acrylic modified silicates may be dissolved by exposure to solvents.

There are some important limitations to the use of silicate coatings, however. While silicates can dry and form a film, the 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 contact and reaction of the silicate with the substrate. For this reason, silicates should not be used on buildings previously painted with organic coatings unless complete removal of those coatings is assured, and pretesting of adhesion and compatibility through mock ups is indispensable prior to large scale treatment.

Silicates are relatively hard, rigid coatings. While they maintain good compatibility with mineral substrates due to similar coefficient of thermal expansion, they cannot bridge working cracks and cannot be applied over sealants or other synthetic materials. They are also difficult to remove from porous substrates and should be considered irreversible.

Finally, silicates are currently more expensive than premium quality acrylic coatings. While this higher initial cost may be a disadvantage, the long service life provided by these coatings can result in a cost advantage when considered over the service life of the coating and the treated building or structure.

### Appropriate Material Selection

Concrete and masonry restoration, decoration, and protection projects have individual objectives, conditions, service exposures, and economic constraints. Although the challenge of selecting among the myriad of available concrete and masonry coating products can be daunting, clear definition of project objectives, performance requirements, and application conditions is the first step in the process of appropriate material selection.

To meet the requirements of the full spectrum of project situations, a diverse range of materials and properties is required. While acrylic coatings will undoubtedly continue to dominate world paint markets due to convenience, moderate cost, and good performance, the use of specialized coatings such as reactive inorganic potassium silicates will also have a place in the market due to longevity, compatibility, and life cycle cost implications.

## Specifying High-Performance Coatings for Concrete

by Thomas E. Remmele

(Extracted from Construction Specifier, 56(9), 2003)

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) of the concrete surface and its moisture 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 UV 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 <sub>2</sub> Diffusion Resistance Coefficient	ASTM E N 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	Measures 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 means 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 in the specifications. In other elevations, for example, 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 should be tested. ASTM D 4541, 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

## Performance Requirements of wall coatings: The Facts and the Fiction

by Marthe Brock

(Extracted from Concrete Repair Bulletin July/August 2006)

How do you compare products? In the construction industry, we read manufacturers' literature, analyze test results, compare performance properties, and review case studies. This works, but how well? An excellent example is elastomeric coatings for exterior above-grade concrete and masonry walls. There are hundreds to choose from—how do you select the best one? All of the necessary information is out there, but what does it mean? If a coating is applied to one building, will it perform the same way on the next? Breathability is important, but is it critical? Elongation is integral, but how much is enough? This article discusses the balance between test methods and product reality, between test results and overall product performance.

### Elongation

Elongation appears to be a very basic concept on the surface. The ability to stretch is not new—just think of a rubber band. In reality, it is not that simple. When looking at elasticity, manufacturers tend to emphasize ultimate elongation, which is just one part of ASTM D 412. The basic procedure for ultimate elongation is to cast a bone-shaped sample of a coating and stretch it until it snaps. How far the coating stretches is recorded as percent of elongation. It is not unusual to see test results in the 500% range. However, is ultimate elongation sufficient to evaluate the ability of an elastomeric coating? Some manufacturers report both ultimate elongation and elongation recovery, which is part of ASTM D 412 as well as Where ultimate elongation measures the plastic behavior of a material, which is a typical property for chewing gum, elongation recovery measures the elastic behavior, which is typical of a rubber band.

The procedure for recovery is similar to ultimate elongation; the difference is the coating sample is not stretched to the breaking point but to 100% over its initial length. The sample length is measured before it is stretched; once the tension is released, the sample is measured again. The desired result is for the material to return to its original shape, which corresponds to an elongation recovery value equal to 100%. This represents a perfect elastic behavior. Any value less than 100% shows that the material has some degree of permanent deformation, which affects its ability to perform over time. No elastomeric coatings report 100% recovery. An excellent elastomeric coating has >95% elongation recovery. This value is affected by the timing of the test

because elasticity tends to be at its peak just after the sample is cast.

Recovery is a more important test than ultimate elongation because it represents the ability of a coating to perform over time, withstanding the daily and seasonal temperature cycles. It may seem that 100% elongation is a limited movement range. The range is necessary because crack movement caused by thermal cycling can go from 2 to 7 mm. Movement greater than that should not be concealed by the coating because it could be a sign of structural movement.

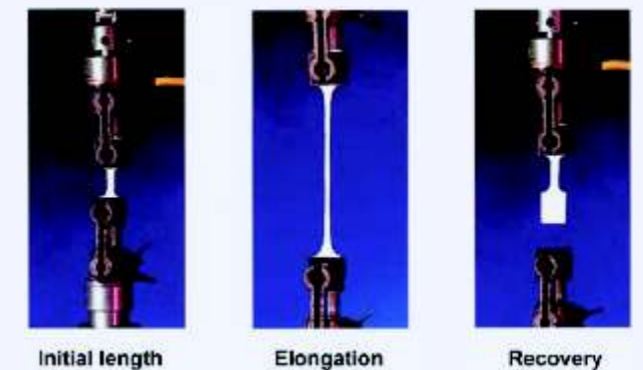


Fig. 1 Elongation and Recovery according to: ASTM D 412

Both elongation and elongation recovery are lab test procedures that provide a good insight about the material behavior but do not represent real-life conditions when the elastomeric coatings are bonded to concrete or masonry. It is the crack bridging test that provides this real-life information. The U.S. standard for this test (ASTM C 1305), however, is designed for liquid membranes applied at 60 mm dry film thickness. Because 60 mm is five times greater than the average thickness of an elastomeric coating, one may question whether it makes any sense to use this test for elastomeric coatings. The argument has some validity. Some manufacturers report the EU for crack bridging of elastomeric coatings. This test measures the ability of the material to withstand a number of crack movement cycles without being damaged. The test is conducted at different levels of temperatures because it is commonly accepted that the elasticity of a material is affected by cold temperatures. Overall, it is a lot of information to be interpreted and evaluated to make the correct product choice! In thinking about cracks, it is important to properly detail and prepare a concrete substrate before the application of elastomeric coatings. Nonmoving cracks should be filled with elastomeric crack filler. Moving cracks should be routed and caulked. Elastomerics bond well to polyurethane sealants, but remember that sealants almost always have more flexibility than coatings, so it is important to use compatible materials in the same color.

Another important detail to consider is bond to concrete. Elastomeric coatings do not have the same bond characteristics as non-elastomeric coatings, which makes surface preparation critical. If the substrate is very smooth, a light brush blast may be required. It is always a good idea to perform a field adhesion test, such as ASTM D 3359. It may show that the substrate requires a primer, or that additional preparation is needed before the coating application. For elastomeric coatings to really perform properly, a continuous pinhole-free film must be applied to the substrate. The reality is a coating's ability to span cracks is directly proportional to the film thickness. That being said, then is more better? Not necessarily.

### Breathability

It seems rather intuitive that the thicker something is, the less breathable it would be. As mentioned previously, breathability is important because a coating is applied to a wall system that must allow for moisture vapor transmission. There is an enormous amount of data available on this topic. One of the challenges is sorting through all this information and making sense of it. There are three common terms used in defining breathability:

- Water vapor permeance.
- Permeability.
- Water vapor transmission

Permeance tells us how much water passes through a film during a specific period of time as induced by a change in pressure. This is expressed in perms. What permeance does not tell us is how thick the film is. Permeance is a performance evaluation, not a property of a material, as stated in ASTM E 96, Section 3.1. Permeability is permeance multiplied by film thickness. This definition is typically only applied to thicker specimens, generally greater than 13 mm, as stated in ASTM E 96, Section 13.3.

Water vapor transmission tells us how much water passes through a film during a specific period of time. What it does not tell us is how much force (change in vapor pressure) drives the vapor or how thick the film is. ASTM D 1653 states "values of water vapor transmission rate (WVT) and water vapor permeance (WVP) can be used in the relative rating of coatings only if the coatings are tested under the same closely controlled conditions of temperature and relative humidity, and their thicknesses are equal." So film thickness is important but it is not part of the definition used to analyze thin film coatings.

ASTM E 96 and D 1653 are the two tests used to measure these properties. Both methods follow the same basic procedure; however, D 1653 does not account for permeability that again relates to film thickness. Why is that important? Say one manufacturer performs D 1653 using a 3 mm sample that results in a perm rating of 35. Is that a relevant result? Three mm would not provide any

crack bridging ability, so would the coating perform in the field as expected? Probably not. On the other hand, say a 10 mm sample is tested that results in a perm rating of 10. Is that enough? How much is enough? There is no criterion in the U.S., thus it is left to interpretation. (Interestingly, German norms provide a value).

To muddy the water even more, let's consider what the U.S. Department of Energy says: "water can move through and into building components in three ways: liquid water leakage and wicking, air currents caused by air pressure differences, and diffusion of water vapor through materials." The first two account for most moisture ingress. In fact, a 13 mm hole in a substrate can allow 24 L of water into a wall system per a single heating season. On the other hand, vapor diffusion only allows 0.3 L of water per heating season. Clearly, a void in the substrate is a larger problem than a film on the surface, again getting back to the notion that proper preparation can make all the difference. Regardless of how the water is getting into a wall system, it has to get out and breathable films will allow that to happen. Figure 2 illustrates what happens when a coating is too thick and is not breathable enough to accommodate vapor drive. This is a problem we all want to avoid.

There is much to consider when selecting coatings for above-grade concrete and masonry. While we have addressed some of the challenging issues here, it is important to remember that comparing products is an inexact science. The process starts with the development of a standard. A scientist in an R&D lab performs the test based on the standard. The scientist provides results to a marketing person who incorporates the information into a technical data guide. A salesperson takes the guide and gives it to an engineer or architect who uses it to compare products. Anywhere along that process, misinterpretation is possible. So what is the answer? Continue to ask questions, provide factual information, and get involved with organizations like ICRI so the dialogue does not stop and the industry continues to improve.



**Fig 2 . Effect of Coating unbreathable to accommodate vapor drive**



Participants & Faculty for 3 - Day **Training Programme for Engineers** on "Advanced Technology For Concrete Repairs" in the month of Jan 08.



Participants & Faculty for 2 - Day **Training Programme for Engineers** on "Usage of Polymeric Materials in Construction" in the month of Feb 08.

**Dr. Fixit Institute of Structural Protection and Rehabilitation** (DFI-SPR) has scheduled a training programme in March 2008. The programme has been designed for upgradation of knowledge base of practicing engineers (Maintenance Engineers, Construction Engineers, Waterproofing & Repair Contractors & Consultants), Architects and Faculty members of Engineering Colleges/Polytechnics in the field.

**TRAINING IN THE MONTH OF MARCH - 2008**

Sl. No.	Date	Location	Topic	No.of Days	Investment
1	12th, 13th, 14th Mar 08	Mumbai	Advances in Concrete Mix Design and usage of Admixtures	3	Rs. 6000/-

**THE COURSE CONTENT**

Sr. No. Topic	Course Content
Programme	<p><b>Advances in Concrete Mix Design and Usage of Admixtures</b></p> <p>Need of Concrete Mix Design (Proportioning) Mineral Admixtures Types of Mix Design Role of Admixtures Latest Admixtures for Self Compacting concrete, HSC etc., Compatibility issues Future Role of Admixtures in Concrete</p>

**Training Calender for year 2008 - 2009**

Sr. No.	Month	Date	No.of Days	Topic	Investment
1	MAY - 08	15 <sup>th</sup> & 16 <sup>th</sup> May 08	2	Waterproofing & Protection of New Structures	Rs. 3000/-
2	JUNE - 08	12 <sup>th</sup> & 13 <sup>th</sup> June 08	2	Repairs and Rehab of concrete structures	Rs. 3000/-
3	JULY - 08	23 <sup>rd</sup> , 24 <sup>th</sup> & 25 <sup>th</sup> July 08	3	Health check of Buildings and Diagnosis of Damaged Structures	Rs. 4500/-
4	AUGUST - 08	28 <sup>th</sup> & 29 <sup>th</sup> Aug 08	2	New Generation Admixtures for Concrete Structures	Rs. 3000/-
5	SEPTEMBER - 08	24 <sup>th</sup> , 25 <sup>th</sup> & 26 <sup>th</sup> Sept 08	3	Waterproofing of Water Retaining Structures	Rs. 4500/-
6	NOVEMBER - 08	20 <sup>th</sup> & 21 <sup>st</sup> Nov 08	2	Role of Polymers in Durability Structures	Rs. 3000/-
7	DECEMBER - 08	18 <sup>th</sup> & 19 <sup>th</sup> Dec 08	2	Cracks and Joints in Structures & Remedial measures	Rs. 3000/-
8	JANUARY - 09	21 <sup>st</sup> , 22 <sup>nd</sup> & 23 <sup>rd</sup> Jan 08	3	State of art Waterproofing of New Structures	Rs. 4500/-
9	FEBR - 09	20 <sup>th</sup> & 21 <sup>st</sup> Feb 08	2	NDT - Diagnostic solution for Dilapidated Structures	Rs. 3000/-

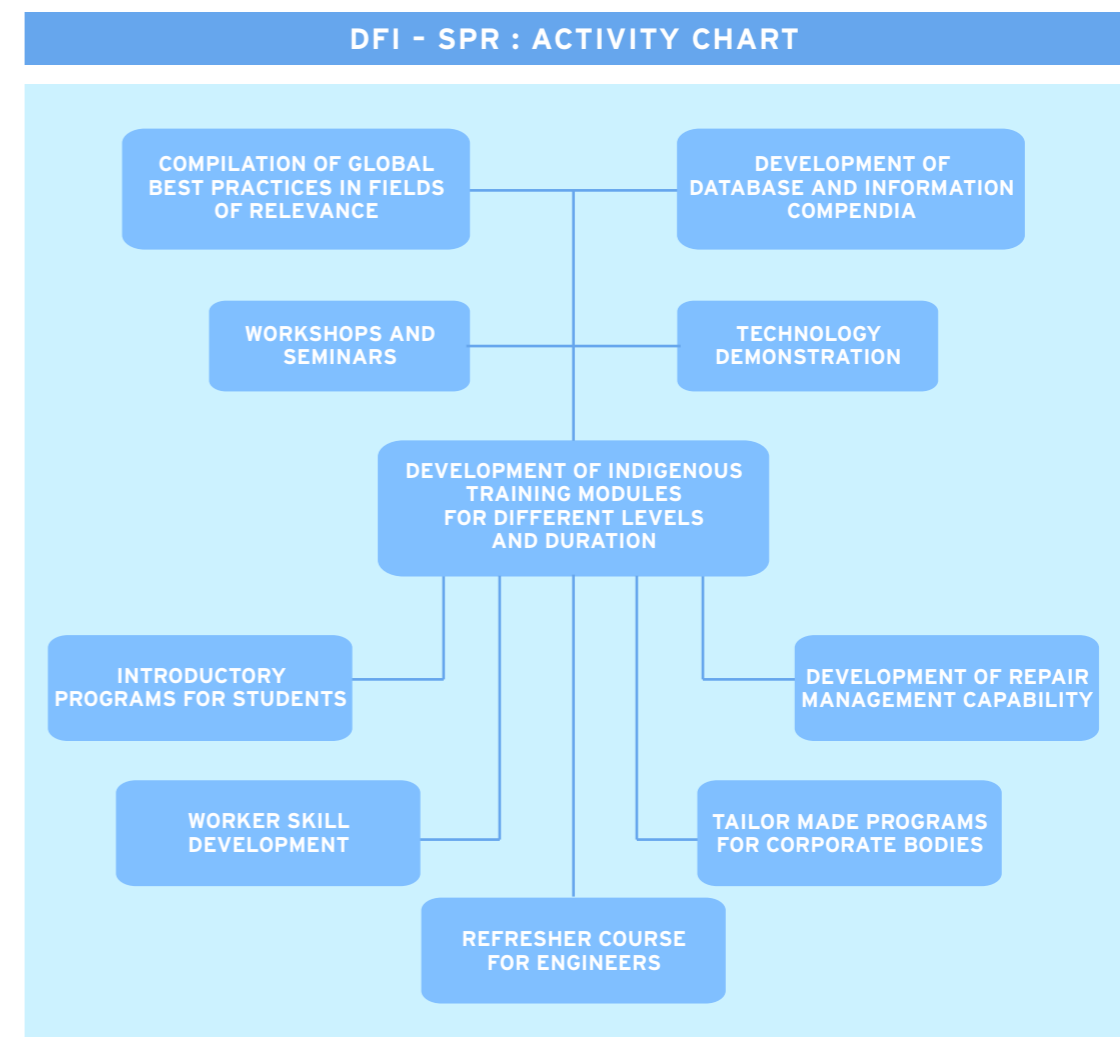
**Note :** Location is Dr. Fixit Institute of Structural Protection and Rehabilitation Premises Andheri (E), Mumbai. For Registration Contact : Ms. Neelima Suryawanshi Sali - 2835 7979 / 9969354030.

**VISION**

To become a premier national knowledge and skill development center in waterproofing and other areas of renewal engineering through international networking in order to proliferate the global best practices in the country.

**MISSION**

The primary mission of the institute will be to act as a platform for enhancing the service life of built environment through global sharing of knowledge and practices in the field of waterproofing, structural protection, repairs and rehabilitation.



**Editorial Advisor :** Dr. A. K Chatterjee, Director, **Dr. Fixit Institute of Structural Protection & Rehabilitation**

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